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REFINER
AND NATURAL GASOLINE MANUFACTURER

SEPTEMBER, 1941
Vol. 20, No. 9

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GRADY TRIPLETT
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CONTENTS

Chemical Conversions of the Lighter Hydrocarbons 67
George Armistead, Jr.

Process Section 77
- Badger Two-Stage Crude Distillation (Asphalt) 78
- Badger Two-Stage Vacuum Lube Distillation 80
- Badger Three-Stage Crude Distillation 82
- Badger Three-Stage Naphtha Redistillation 84
- The Brugma Process 86
- Carrier Distillation Process 88
- Catalytic Alkylation Process 90
- Distillate Recovery 92
- Dubbs Cracking Process 94
- The Edeleanu Process 96
- Foster Wheeler Two-Stage Crude Distillation Unit 98
- Houdry Catalytic Cracking Process 100
- The Hydroforming Process 102
- Knowles Coking Process 104
- Lummus Lubricating Oil Processing System 106
- Lummus Superfractionation Process 108
- Phenol Extraction Process 110
- Polyco Catalytic Polymerization Process 112
- Shell Butane Isomerization Process 114
- Shell Phosphate Process 116
- Sulphuric Acid Alkylation Process 118
- TVP Process 120
- UOP Catalytic Polymerization Process 122
- UOP Isooctane Process 124

Rerun Unit Designed to Operate with Heating Medium and Exchangers 126

Pyrolysis of Several Lower Hydrocarbons in the Presence of Methyl-Chloride 130
H. C. Lu and R. L. Huntington

Rapid Method for Determination of Mercaptan Sulphur in Refinery Caustic Soda Scrubbing Solutions 133
Russell D. Koons

Portable Unit Measures Gas for Gasoline Content 134

Peak of War's Damage to Oil Exports Business Passed 136

Oil Demand Runs High Despite Curtailment of Eastern Use 138
L. J. Logan

Causes and Prevention of Fires and Explosions in the Petroleum Industry 148
G. M. Kintz

DEPARTMENTS

Look Box ..... 65 and 169

Abstracts of Papers Before the Petroleum Division of the American Chemical Society 178

Plant Activities 184

Science and Technology 189

New Equipment 200

Business Notes 206

Catalogs and Bulletins 214

Advertisers' Index 216

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J. KENT RIDLEY, *Managing Editor*
TOM W. NELSON, *Advertising Manager*

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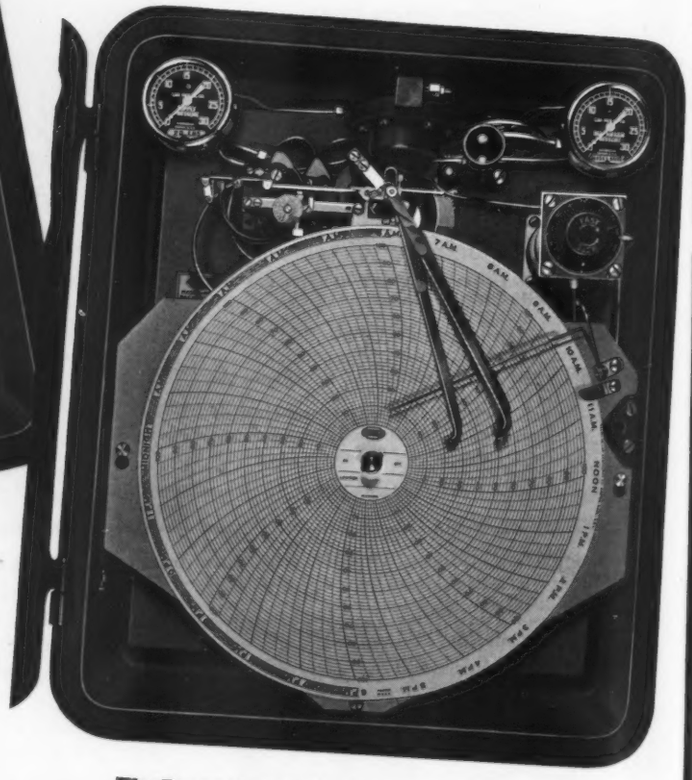

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VOLUME 20, No. 9 SEPTEMBER, 1941

REFINER
AND NATURAL GASOLINE MANUFACTURER

A GULF PUBLISHING COMPANY PUBLICATION

The Look Box

BECAUSE of the national defense program several important refining methods are not included in this annual Process Number of Refiner and Natural Gasoline Manufacturer. Thus publication is deferred in a period when the refining industry is making strides to match the period of the development of cracking. In a general way enough is known to justify the expectation that the petroleum literature will be enriched when it is possible to bring the processes into print.

Publication Deferred

One bit of irony has come to light in the development of toluol manufacture from crude oil. One of the large plants now under construction will use a process which had its beginning in Germany. When there was private industry in that country American industry took advantage of the promises from German research. When conditions made it necessary to dissolve the working agreement, American industry had gained the basis for development of the process.

In part the manufacture of rubber substitutes from the petroleum hydrocarbon had its beginning in German efforts. American scientists have moved far beyond the German contribution and the prospect is that products will be manufactured to meet particular needs in rubber.

If these and other processes were applicable only to the prosecution of war, they could not be counted as wholesome. Fortunately this is not the case. What the refining industry can do in converting the hydrocarbon into materials for military use, it later can do in converting the hydrocarbon into materials for peace-time use. It is this which stamps the unpublicized processes as beneficial.

Having learned how to convert any type of hydrocarbon into any other type of hydrocarbon, the petroleum industry is ready to augment the supply of synthetic products which have been restricted to coal-tar derivatives. In this there is promise that scientific progress in petroleum may contribute to better living out of what it has developed as a part in national defense.

Until there is a change in international relationships, little can be printed about important process development.

SOMEHOW the impression prevails that in the activity of Harold L. Ickes, petroleum coordinator, the accomplishment of control ranks higher than the assurance of oil supplies for England and for national defense. Certainly the rationing of the gasoline supply along the Atlantic seaboard has had more attention from his office than the military supply has had. At least there has been more talk of it.

Doubt Exists Where Facts Are Withheld

His efforts are now directed at cutting down the domestic consumption of this area by one third. Thus far no facts have been advanced to justify the effort. The tankers removed from coast-wise service did reduce deliveries from the Gulf Coast to the Atlantic seaboard. But other methods of transportation plus heavier loading of tankers have offset tanker removal substantially. The public has honest doubt of the necessity of the rationing.

If the effort is based on removal of additional tankers, the public should be given the reason. On the contrary the attitude is that information of this nature must be kept secret because of its value to the Axis powers. But no secret was made of the movement of a tanker of gasoline to Russia. The

two do not make sense and rationing will be difficult as long as there is doubt.

The petroleum coordinator recently made a plea for more refining capacity for 100-octane aviation gasoline and gave the impression that a shortage was impending in that product. The facts are that the industry has more aviation gasoline on hand today than it had a year ago, despite increased consumption.

Along with that the coordinator credited Dr. Robert E. Wilson with misleading the public, the government and the industry by stating that refining capacity was sufficient. It is a matter of record that Dr. Wilson made no such statements. On the contrary he asked for capacity increases, as his remarks at the last meeting of the American Petroleum Institute in Chicago will prove.

Rationing and domestic shortage should be looked upon as regrettable consequences of national defense and prosecution of the war. When these become the primary objective, military needs are not having the attention they deserve.

Under the circumstances it is logical for the public to doubt and for the Congress to investigate the situation in oil. In behalf of the investigation Senator Francis Maloney had this to say of Mr. Ickes: "Sometimes I feel that he is given too much to do and sometimes I fear that in his conscientious effort he is inclined to be dramatic." His full remarks were not intended as a criticism, since he proposed the investigation as a supplement to the work of the coordinator.

Senators of the area threatened with rationing apparently are, like the public, in doubt of the justification of what the coordinator seeks to accomplish.

Nineteen Years Of Progress

SOME last-minute checking before press time brought to light the combination that this issue of REFINER AND NATURAL GASOLINE MANUFACTURER marks the nineteenth anniversary of the publication as well as the largest issue in its history. While the issue is in no sense an anniversary number, it is a comfort to have the two events come as they do. Furthermore, the situation has brought some reflection. It is still vivid in memory that, several years after the publication was started a few men sat around one Saturday afternoon and made plans. Sufficient progress had been made to indicate that the publication had won a place within the industry. There was speculation to the extent that the day would come when it would average 100 pages per month.

The estimate was so far in error that it is almost a reflection to recall it, for it was several years back when as few as 100 pages made up an issue. The figure for September, 1941, is 216 pages plus the cover and the inserts.

Lest these recollections and recordings run into bragging, let it be set down here and now that the refining division of the petroleum industry and the manufacturers of equipment for the division are responsible for the growth. Introduction of the publication came at a propitious time. Manufacturing had no publication. The job of editing was thereby simplified, although by no means made easy. The requirement was to find information of value to the personnel of refining and natural gasoline manufacture. The difficulty was in gaining the privilege of publication. Secrecy pervailed in the industry at that time. Holders of patents wanted nothing printed.

Fortunately that situation was clarified within the industry, whose technical progress has been extensive and in large measure available for publication. Developments in cracking, fractionation, treating, polymerization and other processing of the lighter hydrocarbons have carried the industry into the field of chemical processing.

Long before another 19 years have passed, every indication is that crude oil will have become the source of materials for the manufacture of much that previously has been restricted to coal-tar derivatives.

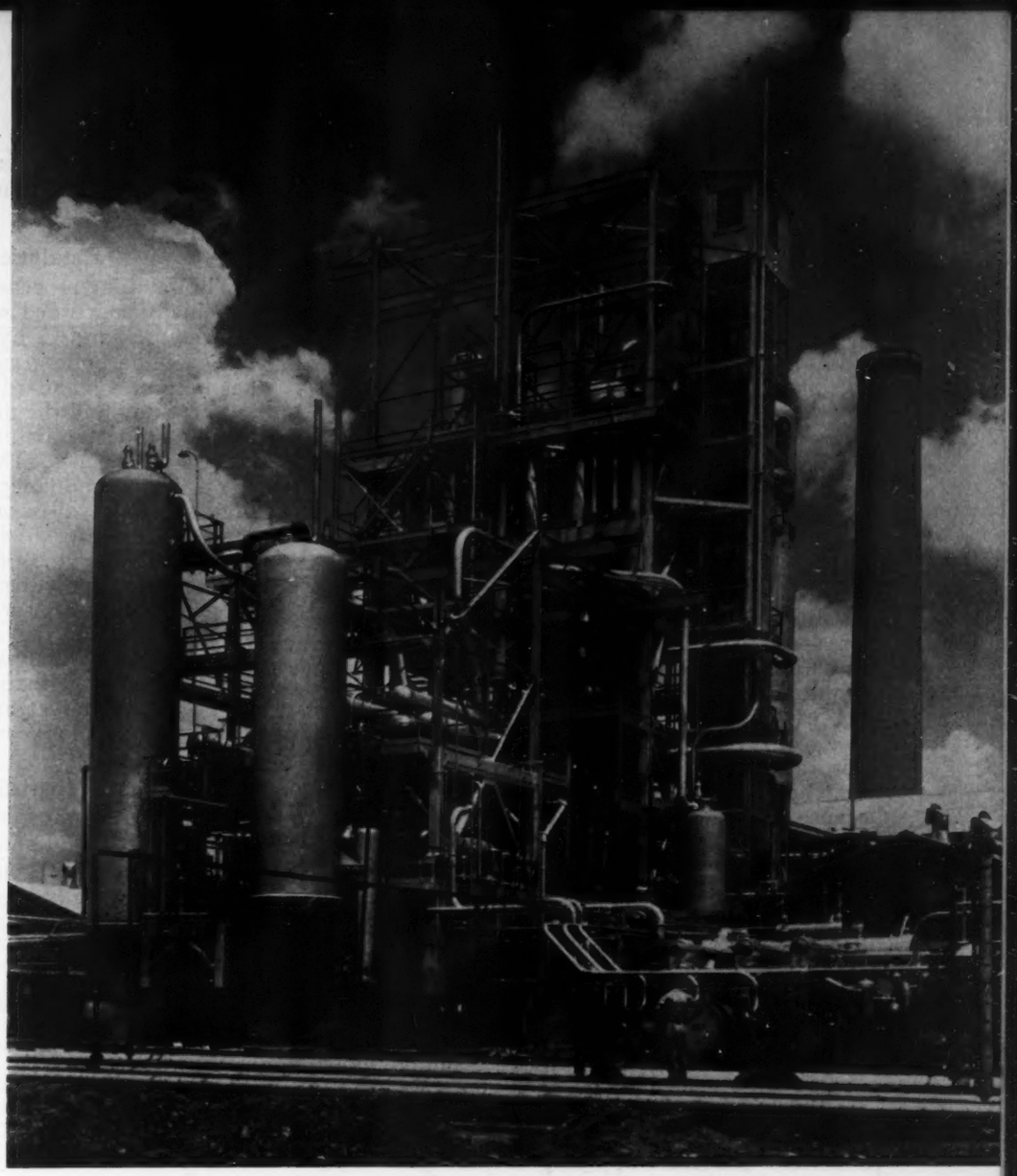
REFINER AND NATURAL GASOLINE MANUFACTURER considers itself fortunate in having had a part in all this development and in having the prospect of holding a place in the larger industry now being developed.

Rationing Is No Accomplishment

THE fanfare of rationing a gasoline supply for the Atlantic Coast states leaves the impression that the Petroleum Coordinator looks upon the rationing of the supply as the objective of his office. The reduced supply is the consequence of striving to get more gasoline to England. When that is accomplished there should be noise making. Until the supply for England and the supply for national defense are adequate it would seem more appropriate for the coordinator to work at the job and spend less energy in his rationing tirades.

If the supply is inadequate for any area, there will be automatic rationing. If the agency of government is going to devote time to determining what user shall have unlimited gasoline and what user shall have reduced supply, it will have little chance to work at the job of gasoline for England and gasoline for national defense.

As to the latter, despite the statements of Harold L. Ickes, there is nothing to indicate that the industry does not have sufficient aviation gasoline at hand plus the disposition and the plants to provide greater capacity in advance of greater need.



Polyform and Gas Reversion.

—Photo Courtesy The Lummus Company

Chemical Conversions of Lighter Hydrocarbons

GEORGE ARMISTEAD, JR.

THE technical literature of refining has been increasingly concerned in recent years with the production of various individual compounds from petroleum by specific and clearly defined chemical reactions. This typifies an important trend within the industry which is enlarging the fields of petroleum utility and at the same time represents a change in the method of approach in refining processes generally. The years from 1925 to about 1935 in the refining industry were notable for the increased understanding and application of chemical engineering such as in the general adoption of efficient fractionating equipment, use of pipe stills for heating, more extensive heat exchange, improvement of cracking technique, uses of alloys, etc. Similarly, the period since about 1932 has been marked by great advances in petroleum chemistry. The industry has not only been able to greatly reduce former wastage of by-product gases but also is able to produce and separate individual hydrocarbons or series for specific purposes. And the indications are that petroleum is becoming the center of a great chemical industry,

TABLE 1
Estimated Production of Light Hydrocarbons—1940[1]

	Natural Gases		Refinery Gases		Total	
	Billions of Cu. Ft. per Year	Tons per Day	Billions of Cu. Ft. per Year	Tons per Day	Billions of Cu. Ft. per Year	Tons per Day
Total Gas...	3,000	.....	260	.....	3,260	.....
Hydrogen..	.....	.....	10	77	10	77
Methane...	2,250	130,000	104	6,000	2,354	136,000
Ethane.....	360	39,000	47	5,100	407	44,100
Ethene.....	.....	.....	13	1,310	13	1,310
Propane....	240	38,000	47	7,450	287	45,450
Propene....	.....	.....	21	3,160	21	3,160
Butanes+..	150	31,500	5	1,050	155	32,550
Butenes....	.....	.....	13	2,650	13	2,650

producing all manner of useful materials not previously associated with it.

A national emergency with its extra demands for special synthetic fuels and numbers of other products including pure hydrocarbons and their derivatives increases the importance of petroleum and natural gas as a chemical raw material. As such they have advantages, including abundance and wide distribution, ease of transportation and a makeup almost wholly of carbon and hydrogen. The most important hydrocarbons for chemical conversions so far have been the lighter ones up to the octanes (C_8), chiefly because of the type and current demand for their derivatives, the fact that many of them lie within the gasoline boiling range and the relatively low number of isomers. It is the purpose of this paper to summarize the various types of conversions applicable to these hydrocarbons, which now are or have prospect of being of particular commercial importance.

Table 1 shows an estimate of the amounts of the lighter hydrocarbons now being produced from all sources, exclusive of the butane fractions ordinarily included in motor gasolines. The columns showing tons per day give some idea of the immense amounts of these materials available.

Figure 1 is a chart outlining the general field of conversion processes applying to the lighter hydrocarbons as well as their uses as such. This includes hydrocarbons making up natural and cracked gases up through a part of these contained in motor gasoline which is about the total range handled by existing processing methods. The left hand column lists the hydrocarbons, the center column indicates the type of processing involved and the right hand column covers the types of products. It should be understood that this chart is intended to cover only the chief methods of processing of commercial importance in early 1941 and does not attempt to outline all reactions of the hydrocarbons in the group.

The processes outlined in Figure 1, which are considered briefly in the following are as follows:

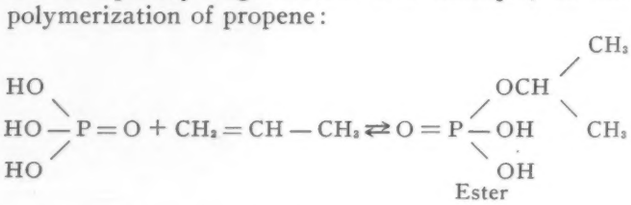
1. Catalytic polymerization
2. Thermal polymerization
3. Gas Reversion (Polyforming)
4. Thermal alkylation
5. Catalytic alkylation
6. Isomerization
7. Dehydrogenation
8. Fischer-Tropsch process
9. Hydroforming and other aromatization
10. Rubber substitutes from petroleum
11. Miscellaneous chemicals from petroleum

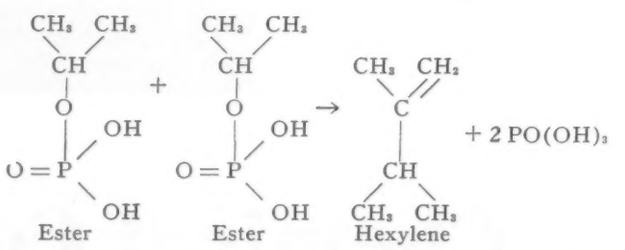
All of these processes have the common denominator of applying to the conversion of the lighter aliphatic hydrocarbons to specific other compounds or classes of compounds by more or less clearly defined reactions.

Catalytic Polymerization

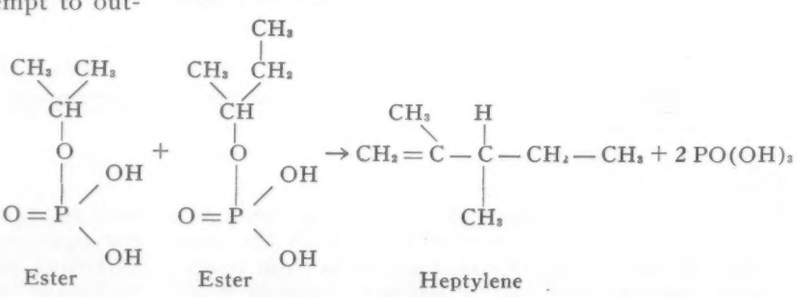
The familiar processes coming under this heading are chiefly concerned with the polymerization of unsaturated C_3 and C_4 hydrocarbons to heavier ones in the gasoline boiling range. Catalytic polymerization has become a standard process for refineries employing cracking and the majority employ it or an equivalent method. It has become an important part of refinery economics. The two general divisions are: (a) selective polymerization, mainly used for the preparation of di-isobutene dimer from butane-butene mixtures for hydrogenation to 2,2,4-trimethylpentane (iso-octane) for aviation gasoline and (b) non-selective polymerization used for converting propene-butene mixtures to a series of C_6 and higher hydrocarbons in the motor-gasoline boiling range. The two most widely used variations are the U.O.P. Catalytic Polymerization[2, 3, 4] employing phosphoric acid as the catalyst and the Polyco catalytic polymerization employing copper pyrophosphate as the catalyst[5, 6, 7].

According to Ipatieff and Corson[10, 11] the reactions involved in the phosphoric acid catalysis involves the intermediate formation of esters from which the acid is subsequently regenerated. For example, in the polymerization of propene:





Corresponding reactions take place between different olefines, forming mixed compounds, for example between the phosphoric esters of propene and ∝butene:

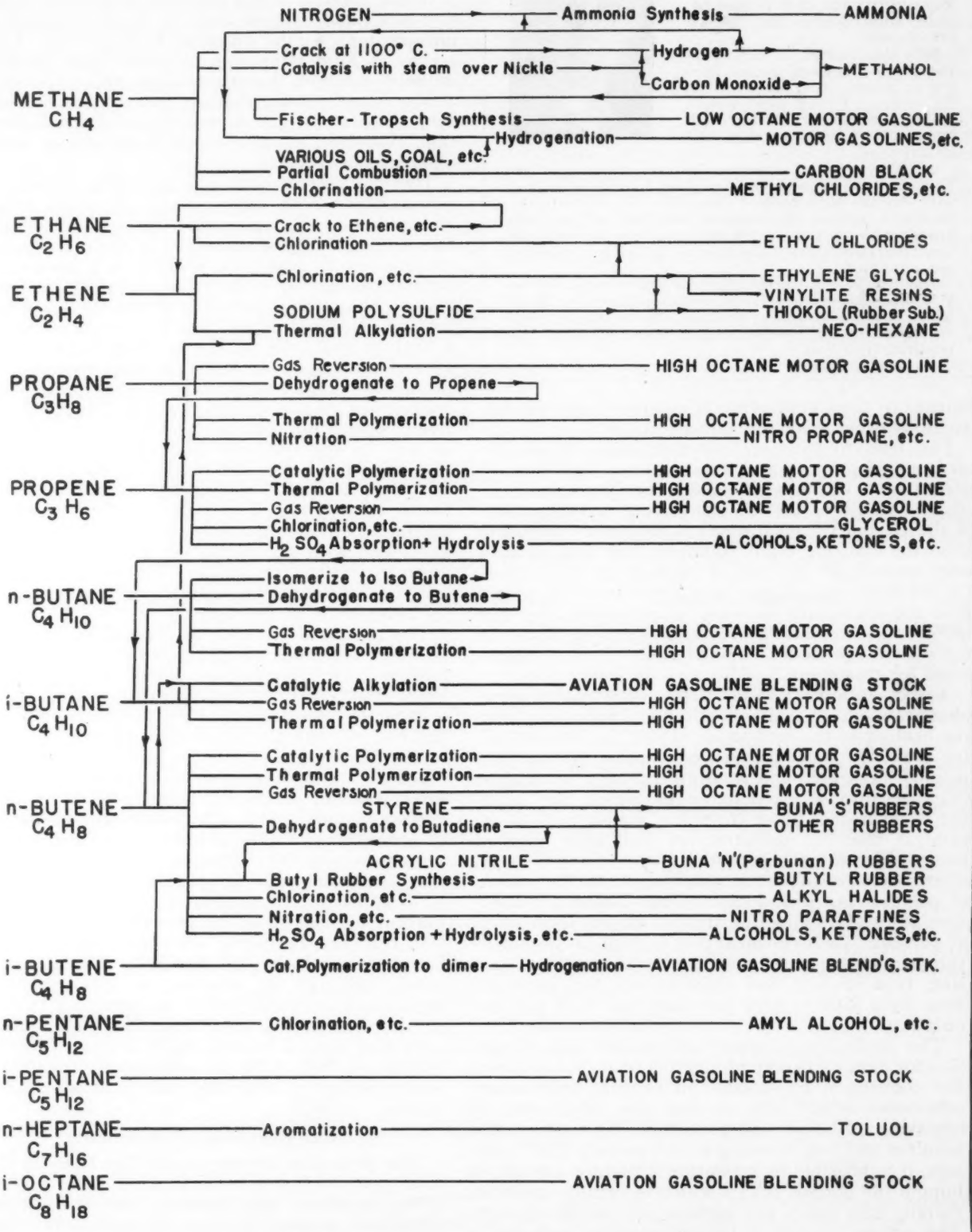


As a result of the branched chain, unsaturated structure of these polymers, the octane number is high.

A number of other substances catalyze polymerization of these olefines, including sulfuric acid, which, in the Cold Acid and Hot Acid processes is used to a limited extent for selective polymerization of

FIGURE I

CHEMICAL CONVERSIONS OF THE HYDROCARBONS



NOTE: *This chart covers only certain commercially important processes and is not an outline of hydrocarbon reactions.*

George Armistead, Jr., has been identified with the refining industry since his graduation from Texas Agricultural and Mechanical College in 1923. This article is the expansion of a lecture he gave there during the 1940-41 school year.

After graduation he went with The Texas Company at the Port Arthur works. Later he went to the Lockport, Illinois, plant where he was assistant cracking still foreman and later technical assistant.

In 1932 he joined Gasoline Products Company, New York, as process engineer. Later he became identified with Process Management Company as process engineer and handled all details of technical services with licensees. In this work he also was secretary of the Cracking Development Conference, a research correlating corporation.

This article was written while he was assistant to the vice president of Republic Oil Refining Company, Houston, a position he took in October, 1939. In August, 1941, he joined the engineering staff of Foster Wheeler Corporation, New York.

butenes in the manufacture of aviation fuels. Similar reactions occur with the sulfuric acid[12].

The feed to catalytic polymerization is usually made up of propene and butene along with varying percentages of more inert hydrocarbons such as ethane, propane, etc. A convenient concentration of the C_3 and C_4 unsaturates is frequently available from the cracking plant stabilizer, but this includes only around 50 percent of their total production. Or the total cracked gas may be treated which will give the maximum recovery of polymerizables but involves greater investment and operating costs. In the selective process a butane-butene fraction is separated for treatment.

The operation of the processes using copper pyrophosphate and phosphoric acid are simple, involving the heating of the feed to about 400° F. (260-325° F. for the UOP selective process) under 700 to 1100 pounds pressure, and passing through a catalyst chamber into a fractionator in which the product is separated. Close control is maintained on the catalyst chamber temperatures, and after catalyst activity decreases substantially it is thrown away. Currently, catalyst life ranges from 60 to 125 gallons of polymer per pound of catalyst. Ultimate conversion of the C_3's and C_4's treated ranges from 85 to 95 percent. The investment cost of catalytic polymerization plants varies considerably depending upon size, type of feed and construction, but generally runs from $300 to $450 per daily barrel of polymer output.

The profitable economics of catalytic polymerization for motor gasoline production result mainly from the conversion to gasoline of propene and butene otherwise usable only as fuel gas. Moreover, by removing all butene (62 pounds RVP) from cracked gasoline and polymerizing it to 2 pounds RVP polymer, it is possible to substitute a greater amount of butane (52 pounds RVP) which is usually available, thereby effecting a net increase in butane recovery. The octane number of the 400-endpoint polymer is 80-84 CFR-M and it has a higher octane-blending value with lower-octane stocks which adds substantially to its economic value. Its lead susceptibility, however, is very poor.

It was estimated by Hubner[13] that about 2 percent of the United States' motor fuel in 1940 would be by polymerization, the major part of which is catalytic.

Thermal Polymerization

Under thermal polymerization comes the conversion of C_3 and C_4 hydrocarbons (both saturated and unsaturated) to the gasoline boiling range by reaction at high temperatures under high pressures without catalyst. Fundamentally, this type of reaction is not wholly distinct from others including dehydrogenation, gas reversion and thermal alkylation. However, it has its own scope of use, distinct from those processes.

Thermal polymerization is generally attractive in situations where a large amount of excess propane and butane is available above that going into gasoline, with or without quantities of the corresponding unsaturates. A supply of propane and butane from natural gas sources is favorable to thermal polymerization. The general principle of the operation is the passing of a mixture of these hydrocarbons through a heating and soaking coil at temperatures of 950-1100° F. and under 1000-3000 pounds pressure, separating the motor fuel product and recycling the unconverted C_3's and C_4's to the coil. Due to the relatively severe temperature and pressure conditions, as well as the relatively low conversion per pass, the investment cost per barrel of polymer product is somewhat high, running $500 or more per daily barrel of polymer. The process offers prospect of maximum ultimate gasoline recovery from C_3 and C_4 gases and wide flexibility, but since the rate of investment return for ordinary refinery use has been less than with catalytic plants, its use has not been so widespread as the latter.

The reactions involved in thermal polymerization are not fully understood. It seems generally agreed, however, as expressed by Keith and Ward[18] and Bogk et al[19] that the process involves both cracking of saturates to olefines and the polymerization of the latter along with alkylation and other reactions more or less simultaneously. Since two or more separate reactions are involved, and these proceed at different rates, it is not practically possible to carry the conversion to completion once through and the recycling of unconverted saturates is necessary for maximum ultimate yields. The ultimate yields of C_4-free gasoline obtainable with practical recycle ratios runs up to 55-60 percent by weight of the butanes and 45-55 percent by weight of the propane. The polymerization reactions occurring are considerably influenced by pressure, which is the reason for the elevated pressures, although the cracking or decomposition reactions are more affected by temperature. The nature of the reactions is such that the product is fairly saturated and of branch-chain structure, having an octane of 78-81 CFR-M and good volatility. Lead susceptibility is relatively low compared to other stocks.

Gas Reversion (Polyforming)

The processes coming under this heading in general comprise those in which the C_3 and C_4 hydrocarbons are heated and digested together with heavier oils such as naphtha, gas oil and heavy residual cracking stocks for two main purposes:[20]

1. To effect polymerization, alkylation, cyclization, and other reactions by and between the C_3 and C_4 hydrocarbons and the heavier oil being cracked.
2. To dilute the heavier oil to permit higher conversion per pass.

As in thermal polymerization, the mechanisms of the reactions occurring are not well understood, principally because of their apparent number and variety. According to Bogk et al[19] it is considered certain that in naphtha gas reversion a substantial portion of the naphtha is converted into gaseous olefines and some paraffines. These, along with any extraneous paraffines that may be introduced to the system, undergo polymerization with olefine polymerization predominating and alkylation taking place to a minor degree. Under certain conditions in this operation, it is possible to make a product high in aromatics[20, 21] such as toluol and xylol, which compounds can be separated if demand requires. Similar reactions would seem to occur in the other adaptations of reversion or polyforming with gas oil and residuals. Evidence has been presented[19] indicating a considerable yield increase by self-contained polyforming (recycling its own C_3 and C_4 gas to coil) over straight naphtha reforming to the same octane plus thermal polymerization of C_3's and C_4's. The net effect of this appears to be a raise in the octane ceiling obtainable by noncatalytic reforming and gas oil cracking above that obtainable with comparable losses when using thermal reforming or cracking plus thermal polymerization. Lead response of reversion gasolines is in generally the same range as thermally cracked gasolines.

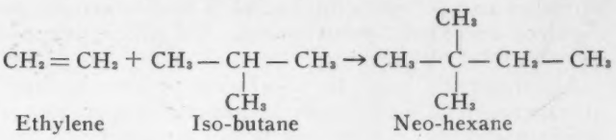
Gas reversion is also useful in the converting of outside C_3's and C_4's to motor fuel in connection with a reforming or cracking operation. The propane in such stocks is more difficult to convert than the butane and both are more difficult than the corresponding unsaturates. Depending upon the recycle ratios employed it is feasible to bring the C_3 content of the final gas produced to a very low figure and the C_4 content to zero or near it.

The polyform-gas-reversion processes have been sponsored chiefly by Phillips Petroleum Company and Gulf Oil Corporation, both of whom are operating the processes extensively. Published data[19] on costs indicate an investment of about $135 per daily barrel and direct operating cost of about 13 cents per barrel for a 5000-barrel self-contained naphtha-polyform unit, both somewhat above similar costs on thermal naphtha reforming. Since the gas reversion processes are not radically different in nature from conventional cracking it is possible in some cases to adapt existing equipment to its use although the higher recycle ratios, pressures, etc., require adequate provisions.

Thermal Alkylation

The term alkylation as generally applied to the conversions of hydrocarbons is the union of dissimilar hydrocarbons usually including some olefines to form a heavier saturated hydrocarbon. Such unions can be effected by high temperature, high-pressure soaking of certain selected olefine-paraffine mixtures, the most important of which at present is the synthesis of Neo-hexane announced by Phillips Petroleum Company in 1939.[22]

A typical reaction of thermal alkylation is the formation of neo-hexane (2,2-dimethyl butane) from ethylene and iso-butane under conditions of 920-960° F. and 4500 pounds pressure is as follows:



Ethylene — Iso-butane — Neo-hexane

According to Oberfell and Frey[22] alkylation by thermal means can be made to produce a number of products, for example, by reaction of ethylene and propane to form iso-pentane and some n-pentane, ethylene and n-butane to form 3-methyl pentane, propylene and propane to form 2,3-dimethylbutane, ethylene and iso-butane to form neo-hexane as above. They point out that thermal alkylation reacts most readily the lower olefines (ethylene) in contradistinction to catalytic alkylation which reacts butenes most readily and ethylene with difficulty.

The development of thermal alkylation has opened up a most important field for syntheses from petroleum, and the product of immediate interest is neo-hexane. This is a 94 CFR-M-octane hydrocarbon having a boiling point of 121° F. which has important advantages for aviation gasoline, in volatility and maximum octane obtainable with lead.

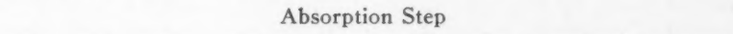
No cost information is available on thermal alkylation plants, but it is understood that costs are in the same general order as thermal polymerization. It is necessary in the manufacture of neo-hexane by this method, to have a source of ethylene, for which purpose a mixture of C_2 to C_4 saturates is cracked at 1450° F. and atmospheric pressure.

Catalytic Alkylation

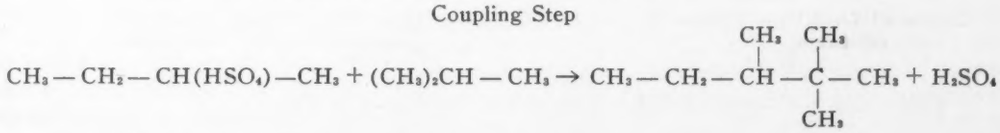
This process is currently the most important source of the 94+-octane constituent used in 100-octane leaded aviation fuels. As in the case of thermal alkylation, it comprises the joining of an olefine with an iso-parafin, but at low temperatures and pressures in the presence of a catalyst. Numerous catalysts are useful in effecting this reaction, including sulfuric acid, aluminum chloride, boron fluoride plus nickel, sodium chloroaluminate and others.[23,24] Sulfuric acid is the catalyst in current commercial use.

The main use of catalytic alkylation at present is for the reacting of butylene and iso-butane to form the branched chain 2,2,4 trimethyl pentane and similar octanes. The reaction by which this takes place is considered to include the intermediate formation of a sulfuric acid ester by the butene,[24] and is shown below:

Absorption Step



Coupling Step



The net result is the combination of one molecule of butylene with one molecule of iso-butane to form one molecule of iso-octane.

This reaction is exothermic and is carried out at temperatures of 30-50° F. which usually requires refrigeration or other cooling means for maintaining the temperature level. The sulfuric acid is used at a

concentration of 90 percent and higher, and after a period of use becomes diluted with hydrocarbons and requires reconcentration or use for other purposes such as lube oil treating.

Although the catalytic alkylation process is simple in essence, the equipment is expensive per unit of alkylate output, chiefly due to the necessity of fractionating two practically pure hydrocarbons as feed stocks for the process, a factor which is necessary for proper functioning. The total costs of complete plant including the preparation equipment (for separating the feed constituents from available gases or natural gasoline) will run as much as $1500 and over per daily barrel of alkylate capacity. The 92-96 CFR-M-octane product of catalytic alkylation mixed in about the proportions of 40 percent with 45 percent of 73-octane straight-run gasoline and 15 percent of isopentane and with 3 cc lead will give 100 octane gasoline by the new AN-VV-F-746 method. Despite the investment cost such plants show rapid payout possibilities when the alkylate can be marketed at 16 cents per gallon or more and the iso-butane and butylene are readily available. One of the chief limitations to the extent of use of the process is the supply of iso-butane and difficulty of separating it.

The sulfuric acid alkylation process was developed through the combined research efforts of Anglo-Iranian Oil Company, Humble Oil & Refining Company, Shell Development Company, Standard Oil Development Company and The Texas Company, and is licensed by Universal Oil Products Company and the M. W. Kellogg Company.

Isomerization

The extensive use of the sulfuric acid alkylation process for the production of aviation gasoline blending stocks has made isomerization of much interest as a possible means of increasing the supply of iso-butane available for alkylation. It has also certain other uses in connection with raising octane of gasoline.

Isomerization, as applied to hydrocarbons may be considered generally as the alteration of molecular structure without change in the number of carbon and hydrogen atoms present. Commercial operation of this process is just beginning and although considerable research has been in progress for some years, there is little literature on the subject. It has been reported, however, by Russian investigators[25,26] that butane can be isomerized readily to iso-butane under mild temperature conditions in the presence of aluminum chloride catalyst with yields as high as 74 percent of the theoretical. Ipatieff et al[32] conclude that the mechanism of isomerization taking place among other reactions by normal hexane in the presence of aluminum chloride, water and hydrochloric acid is in the following two stages:

$$\underset{\text{n-hexane}}{CH_3-CH_2-CH_2-CH_2-CH_2-CH_3} \rightarrow \underset{\text{n-butane}}{CH_3-CH_2-CH_2-CH_3} + \underset{\text{ethylene}}{CH_2=CH_2}$$

$$CH_3-CH_2-\underset{\displaystyle H}{\overset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-CH_3 + CH_2=CH_2 \rightarrow CH_3-CH_2-\underset{\displaystyle CH_2}{\overset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-CH_3$$

$$\underset{\text{n-butane}}{\quad} \qquad \underset{\text{ethylene}}{\quad} \qquad \underset{\text{iso-hexane}}{CH_3}$$

At the present time two isomerization plants are in operation in foreign countries and another is under construction in the United States. According to reliable estimates, one type of plant will require an investment of about $350-$400 per daily barrel for capacities in the range of 700-1000 barrels and can be operated for about 1¼ to 1½ cents per gallon of product. It is understood that isomerization in combination with alkylation and possibly the dehydrogenation of butanes to butene, for the production of aviation fuels from natural gasoline sources is estimated to involve an initial investment of around $2000 per daily barrel of alkylate capacity.

Undoubtedly the commercial development of paraffin isomerization will be considerably dependent on the trend of the future market for aviation fuels, and the parties most affected will be the natural gasoline producers and others with large supplies of normal butane.

Another form of isomerization reported to be in immediate commercial prospect is applicable to cracked gasolines for effecting a moderate increase in octane rating by rearranging molecular structure to the branch chain form. No details of this process have been announced, but it will probably find its most important application to cracked gasolines produced under conditions not conducive to high initial octane, or which may be particularly receptive to this type of treatment.

Dehydrogenation

The term dehydrogenation applied to commercial operations generally refers to the removal of hydrogen from the lighter paraffin hydrocarbons to form olefines which are polymerizable to high-octane motor fuel or otherwise usable for special purposes. This action also occurs as a more or less inseparable part of the processes of thermal polymerization, gas reversion, hydroforming and dehydrocyclization which are described separately.

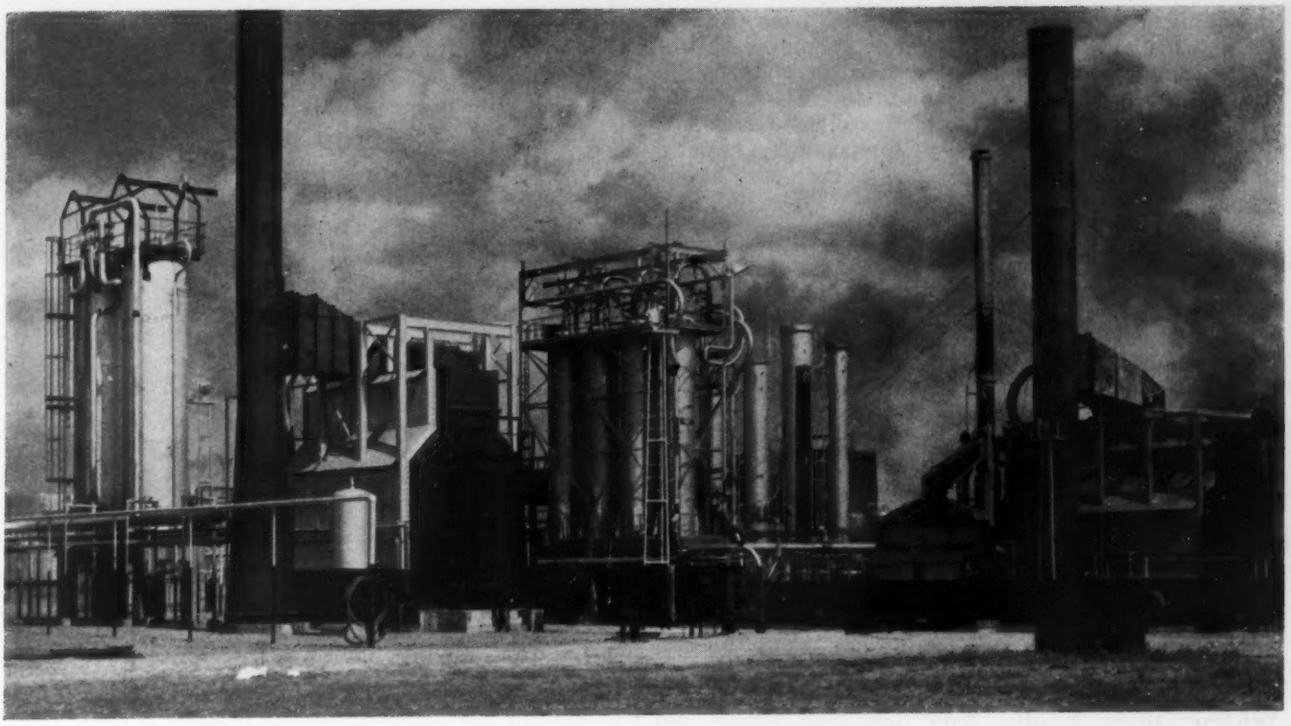
Dehydrogenation, in its usual sense, may be carried out either thermally or catalytically. The basic reaction in the dehydrogenation of a paraffin is as follows:

$$C_nH_{2n+2} \rightarrow C_nH_{2n} + H_2$$

In the dehydrogenation of the lighter paraffins, there are invariably other reactions occurring to a greater or less degree in which the carbon-carbon bond is broken, leading to the formation of other hydrocarbons. This is much more prevalent in the thermal process than in the catalytic version and thermal dehydrogenation is perhaps more significantly referred to as gas cracking or gas pyrolysis.

The dehydrogenation of ethane, propane and butane are of the primary commercial importance, the ethene being usable in thermal alkylation to form neo-hexane and propene and butene in catalytic polymerization or catalytic alkylation to form high-octane motor fuels. Also, dehydrogenation to the extent of forming diolefines such as butadiene has recently become of much commercial importance because of the value of this material as a base for rubber substitutes.

Examples of these plants are described by Egloff, Morrell and Nelson[27] where a mixture of light hydrocarbons is cracked at 1065-75° F. and 750 pounds to make an olefinic feed for catalytic polymerization and by Oberfell and Frey[22] in which ethane, propane and butane mixtures are cracked at 1400° F. and near-atmospheric pressure to obtain ethylene for thermal alkylation. Since the thermodynamics



U. O. P. Catalytic Polymerization

involved generally favor the rupture of the carbon-carbon bond rather than dehydrogenation, the yield of olefines by the reaction shown in the foregoing is not good and the production of paraffins and olefines with smaller numbers of carbon atoms predominates.

Much improved yields of olefines by catalytic dehydrogenation are reported by Grosse et al[9] employing a chromium oxide catalyst on alumina. This indicates the possibility of securing 90 percent or more conversion of the C_2, C_3 and C_4 paraffins to the corresponding olefines and the scission of the carbon-carbon bond has been almost wholly suppressed. The process operates at atmospheric pressure and 500-700° C. Similar results have been reported by other investigators, in most of which work the chromium oxide catalyst on alumina appeared to be of the most importance. One commercial catalytic dehydrogenation plant of this type is understood to be in operation in a foreign country.

For the production of diolefines, it is understood that butadiene is being made commercially by thermal dehydrogenation (gas cracking) at several plants[31] as a by-product of other olefine manufacture and it is now being produced in commercial quantities for the manufacture of rubber substitutes. It is reported also that one or more catalytic dehydrogenation plants are in prospect of erection.[31] One form of catalytic process as reported by Grosse et al[28] employs chromium, molybdenum and vanadium oxides or mixtures on alumina at low pressures and 600-650° C. for the dehydrogenation of butene to butadiene and branched pentenes to isoprene. These processes have prospect of becoming very important as the source of raw materials for synthetic rubber substitutes. The very important long-range possibilities for the production of rubber substitutes and other products for which dehydrogenation is an intermediate step can be seen from the large quantities of individual hydrocarbons available in the United States as shown in Table 1 and in previously published similar data by Egloff[9] who emphasized the same point.

Fischer-Tropsch Synthesis

This is a process for the synthesis of motor fuels and other light hydrocarbon oils from carbon monoxide and hydrogen. The process was developed in Germany about 1926 and its use has so far been restricted to that country and Japan where coal coke is employed as the basic raw material. It has been the subject of some investigation in the United States in recent years as a possible means of converting methane to motor fuel. At the present stage of development, however, investment and operating costs are so high that the process is unattractive to any but the economies such as Germany where self-sufficiency is sought at any cost. In Germany it is used to a lesser extent than hydrogenation of coal and lignite for the production of synthetic fuels.[17]

Carbon monoxide and hydrogen can be prepared from methane by reaction with steam over a nickel catalyst.

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Where the basic material is coal as in Germany, the carbon monoxide and hydrogen are prepared by the water gas reaction.

The Fischer-Tropsch synthesis requires that certain proportions of carbon monoxide and hydrogen be present, depending upon the range of products desired, and other reactions may be employed to adjust the quantities. The mixture is passed over a catalyst which may be composed of nickel, cobalt, copper with other compounds and a typical reaction is considered[15] to be as follows:

$$nCO + (2n + 1)H_2 \rightarrow C_nH_{2n+2} + nH_2O$$

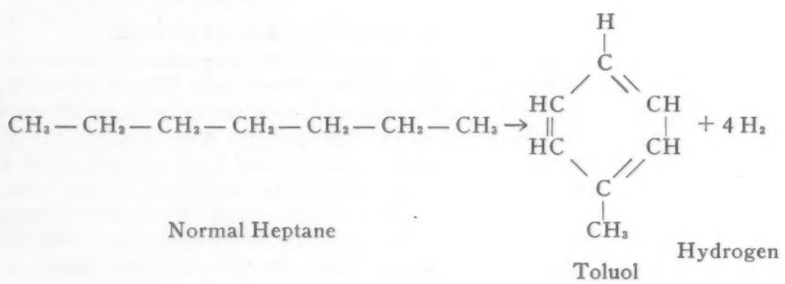
The yields are some 80-85 percent of the theoretical and the product, known as kogasin (kohle+gas+benzin) is a mixture of hydrocarbons boiling from the gasoline range up through gas oil and even

extending into the paraffin wax hydrocarbons. Since the product in the motor-fuel range is composed predominately of straight-chain hydrocarbons, the octane number is low, being about 40 CFR-M on the 400-end point fraction. Egloff, Morrell and Nelson[16] report the reforming of some of the product, showing that it can be raised to 66 CFR-M octane with about 84 percent yield.

Hydroforming and Other Aromatization

Aromatization is the general term applying to processes for the converting of aliphatic hydrocarbons to the aromatic or benzene series. Hydroforming is a catalytic process for this purpose in which heavy paraffinic naphtha, for example, is converted in part to benzene hydrocarbons by passing over a catalyst in the presence of hydrogen. Several commercial hydroforming installations are in commercial use or building. The process may be used simply for the improvement of octane number and when operated on selected stocks and under special conditions, for the production of toluol, xylol and other aromatics. Aromatization may also be effected thermally, as in the gas reversion process, making products from which the individual benzene hydrocarbons, toluol, xylol and others may be separated.[21]

The conversion of aliphatic hydrocarbons to the benzene series involve both dehydrogenation and cyclization and Grosse et al[33] have termed the process dehydrocyclization. In general the mechanism of these reactions is typified by the conversion of normal heptane to toluol:



The production of 70-90 percent of the theoretical yield of toluol from normal heptane using catalysts from the group including oxides of chromium, molybdenum and vanadium on alumina or magnesia was reported by Grosse et al.[33] While the reaction mechanism under such conditions is fairly easily established, the reactions taking place in thermal aromatization such as in gas reversion are less clearly defined and in all probability include both the reaction above along with other types of cyclization and dehydrogenation.

The first commercial hydroforming unit was erected by Pan American Refining Corporation at Texas City, Texas, for handling as feed about 7500 barrels daily of 40-45 CFR-M heavy naphtha and raising to 80 CFR-M with about 80 percent yield.[34] The operation is simple in principle, consisting in vaporizing the naphtha feed and passing through a chamber containing a granular catalyst at about 1000° F. along with a preheated stream of hydrogen-containing gas derived from the end products of the process. As the reaction proceeds in the reaction chamber, coke is deposited on the catalyst, decreasing activity and requiring switching to another chamber while the coke deposit is burned off. The equipment for the purging, burning carbon and other operations on the catalyst chambers is complicated and expensive, but with proper control equipment can be made automatic, and the time cycle for each chamber is not too short.

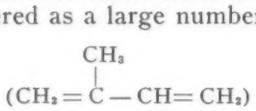
According to Smith and Moore[34] the hydroforming product described above contains some 40-50 percent aromatics of which about one sixth is toluol with most of the remainder being xylol and heavier aromatics. It is stated that with properly modified conditions as much as 80 percent of aromatics can be produced, which makes the process an important source of toluol for military purposes. It is probable that the hydroforming process can eventually be adapted to the moving bed arrangement recently developed in catalytic cracking with a substantial decrease in equipment costs.

The hydroforming process is a development of the research of several companies including Standard Oil Company (Indiana), and Standard Oil Development Company and is being licensed by Standard Catalytic Company. The catalyst used in the process has not been announced.

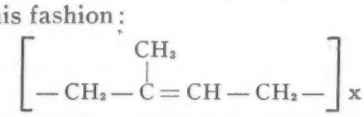
Rubber Substitutes from Petroleum

Natural rubber is a hydrocarbon, and for years more or less successful attempts have been made to synthesize it or similar products having its elasticity, strength, etc. Efforts have been renewed in the United States in recent years under the influence of war conditions in the Far East which threaten the supply of natural rubber. The abundance of petroleum hydrocarbons in this country favors the manufacture of such synthetics although competition with natural rubber on a price basis is not yet in sight.

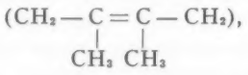
The natural rubber molecule is made up of what may be considered as a large number of isoprene



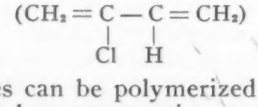
units in this fashion:



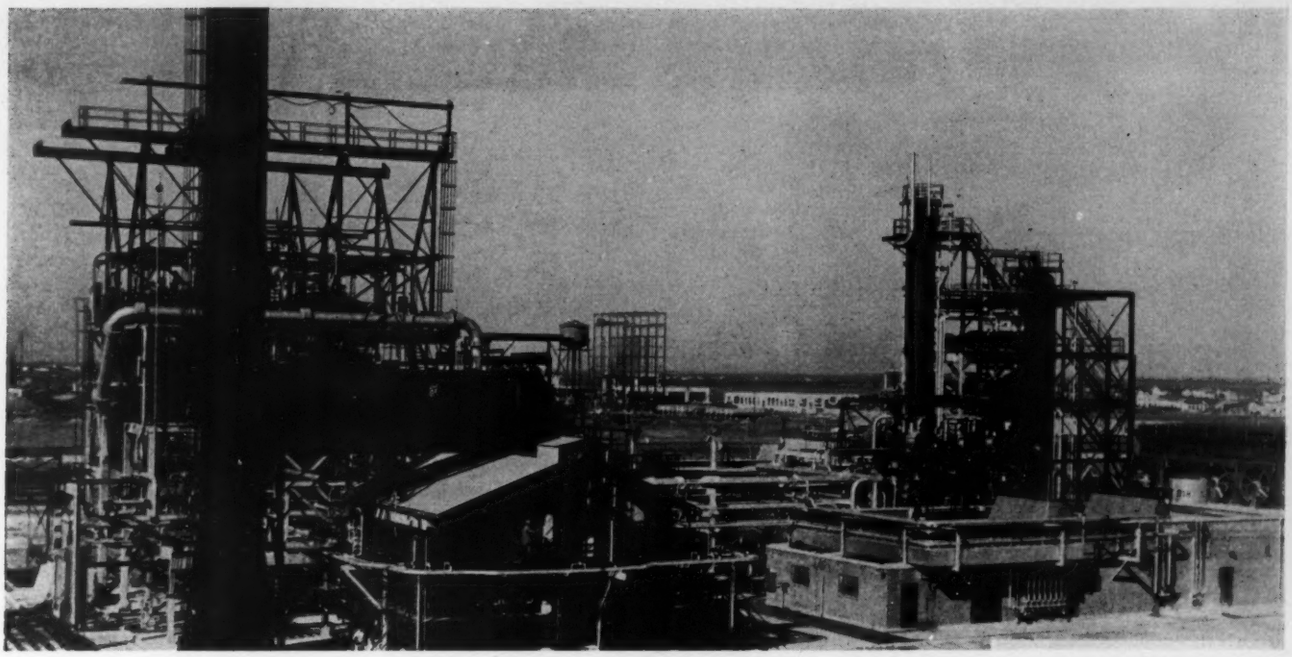
Isoprene can be polymerized to a rubber-like material, which, however, does not duplicate natural rubber in all respects. Also, other petroleum hydrocarbons or their derivatives including butadiene (CH_2=CH—CH=CH_2), dimethyl butadiene



chloroprene



and the butenes can be polymerized to similar substances which have properties superior in some respects and inferior in others to natural rubber. A number of such synthetics are on the market at present. The most important base materials are the



Hydroforming Process —Courtesy The M. W. Kellogg Company

C_4 hydrocarbons. This is reflected in considerable activity in manufacture of C_4 diolefines as mentioned under "dehydrogenation."

The most important classes of synthetic rubber substitutes are listed in the following. With possibly two exceptions these materials can be made in major part from petroleum raw materials. For comparison of costs, natural rubber currently costs about $11.50 per cubic foot.

Neoprene

A polymer of chloroprene (made from vinyl acetylene) not presently derived from petroleum sources. Typical unit of the polymer:

$$-CH_2-\underset{\displaystyle Cl}{\overset{|}{C}}=CH-CH_2-$$

Also called sovprene. Cost about $50.00 per cubic foot. Elasticity medium high. Resistance to solvents excellent. Oxygen resistance excellent. High temperature toughness poor. Strength high. Handling qualities fair to good.[36]

Production 500 tons per month.[37] Made by duPont.

Buna S

A copolymer of butadiene and styrene (vinyl benzene), typical reaction of which is:[34]

$$CH_2=CH-CH=CH_2 + CH_2=\underset{\displaystyle C_6H_5}{\overset{|}{C}}H \rightarrow -CH_2-CH=CH-CH_2-CH_2-\underset{\displaystyle C_6H_5}{\overset{|}{C}}H-$$

Not manufactured in America. Costs reported from Germany[31] indicate in the same range as natural rubber which appears doubtful.[38] Strength good. Resistance to solvents poor, almost same as natural rubber. Resistance to abrasion excellent. Handling qualities good. Used to a large extent in Germany for tire treads and mechanical rubber goods,[41] the butadiene being derived from acetylene.[34] [40]

Perbunan

A copolymer of butadiene and acrylic nitrile (vinyl cycanide) also called Buna N. Typical reaction and unit of polymer:[34] [41]

$$CH_2=CH-CH=CH_2 + CH_2=\underset{\displaystyle CN}{\overset{|}{C}}H \rightarrow -CH_2-CH=CH-CH_2-CH_2-\underset{\displaystyle CN}{\overset{|}{C}}H-$$

Cost reported as about $50.00 per cubic foot for imported material[31] [35] although much lower prices are hoped for, in the range of $15.00 to $25.00 per cubic foot.[31] [42] Excellent resistance to solvents and oxygen. High strength with carbon black. Elasticity medium. Handling qualities so difficult that cannot be used for tires without modification.[36] One 5-ton per day plant being built by Standard Oil Company of Louisiana at Baton Rouge and others contemplated.[39]

Butyl Rubber

A copolymer of olefines with a small amount of di-olefines, developed by Standard Oil Development Company.[43] No announcement has been made of its exact character or the reactions involved in its formation. Full commercial plant production not yet achieved.

Resistance to solvents poor. Elasticity good. Resistance to oxidation good. Resistance to abrasion good. Handling qualities good.

Cost not announced, but according to statement of W. S. Farish of Standard Oil Company (New Jersey)[44] it will probably be below that of Perbunan, suggesting a figure around $20.00 per cubic foot.

Ameripol

A product from butadiene and other materials, whose details have not been announced. Made by the B. F. Goodrich Company, which indicates that the material can be fabricated into tires with same machinery as used for natural rubber.[44] Goodrich is cooperating with Phillips Petroleum Company in production of Butadiene, through Hydrocarbon Chemical & Rubber Company.

Chemigum

A butadiene copolymer, but using an undisclosed other material as a substitute for the styrene or acrylic nitrile.[35] Manufactured on limited scale by Goodyear Tire & Rubber Company.

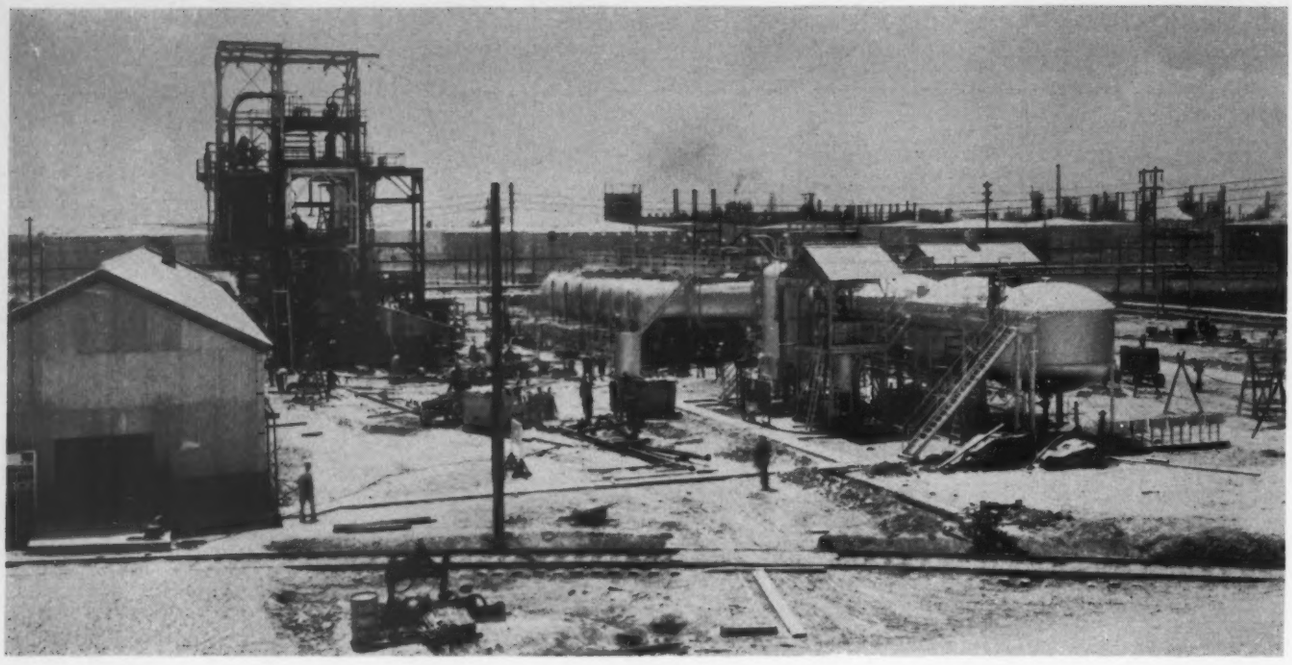
Synthal

A material of unannounced composition produced on a limited scale by United States Rubber Company. Stated to be generally similar to the Buna rubbers.

Thiokol

This material is a product of organic chlorides and a metallic polysulfide forming a polymer-like material possessing elastic properties and excellent resistance to solvents, but lacking in strength, toughness and resistance to heat of natural rubber. Manufactured by Thiokol Corporation chiefly for special purposes.

In addition to these, there are also several similar substances of lesser importance for general rubber uses including koroseal, a polymer of vinyl chloride;



Synthetic Rubber and Chemical Processing.

Vistanex polybutene, a polymer of isobutene; the straight butadiene polymers e.g., buna 85 and the Russian products SKA and SKB; and methyl rubber from dimethyl butadiene.

Miscellaneous Chemicals from Petroleum

The production of numerous specific chemicals such as iso-octane, toluol, butadiene, etc., have been described in the foregoing. In addition to these there is a large number of other products derivable wholly or in part from it, and only the barest outline of this can be covered here. Important manufacturers of miscellaneous chemicals from petroleum include Standard Oil Company of New Jersey, Shell Chemical Company, Carbide and Carbon Chemicals Corporation, Monsanto Chemical Corporation, Dow Chemical Company, Sharples Solvents Company and others.

Cracked gases with their substantial olefine content are a primary source of chemicals starting with the sulfuric acid absorption of the olefines followed by hydrolysis and other reactions producing a variety of alcohols, ketones, ethers and other products. Acetone is being prepared from propylene by first converting it to isopropyl alcohol and then dehydrogenating to acetone.[45] Ethyl alcohol is prepared from ethylene. Amyl alcohol and its derivatives are prepared from the chlorination of pentane. By chlorination of ethylene followed by other reactions, ethylene glycol is prepared by Carbide and Carbon Chemicals Corporation. Recently, Shell Development Company has announced a process for making glycerine from propylene employing a high temperature chlorination step developed by them.[46] A plant has recently been erected for the nitration of paraffin hydrocarbons.[47] Shell Chemical Company is cracking natural gas at high temperatures to separate hydrogen for subsequent use in a high-pressure ammonia synthesis.[8]

The progress in syntheses from the petroleum hydrocarbons in recent years suggests that far-reaching effects are in prospect. Already a number of chemicals such as iso-octane and toluol are being produced in quantities difficult or impossible to achieve otherwise. The potential production of others is serving as a brake against inordinate price rises. And the almost unlimited quantities of the raw materials indicates that the trend should be toward the manufacture of new products to fill existing uses or for which new uses will be found.

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Foreword

REQUIREMENTS for national defense and for the warring countries of Europe dominate the trend in refining process for 1941. Chiefly this is for the production of 100-octane aviation gasoline.

Fortunately the industry had the processes at hand when the demand for this grade of gasoline became acute. All it needed was addition to plant capacity and perfection of processes already in commercial operation or at the pilot plant stage.

It is these processes which are presented in the following list of processes. Few of them are new, but distinct changes are recorded in both descriptive text and flow diagrams.

In addition to aviation gasoline, the industry has ventured into chemical processing with toluol and synthetic rubber as the processes already in commercial stage. Because of the military situation it is neither wise nor possible to offer these processes. Holders of licenses have asked that nothing be printed on any of these processes.

In addition the following processes also record changes in manufacture of ordinary gasolines and lubricants.

INDEX FOR THE FOLLOWING PROCESSES IS ON PAGE 1 OF THIS ISSUE

Two-Stage Crude Distillation

ASPHALT

E. B. BADGER & SONS COMPANY

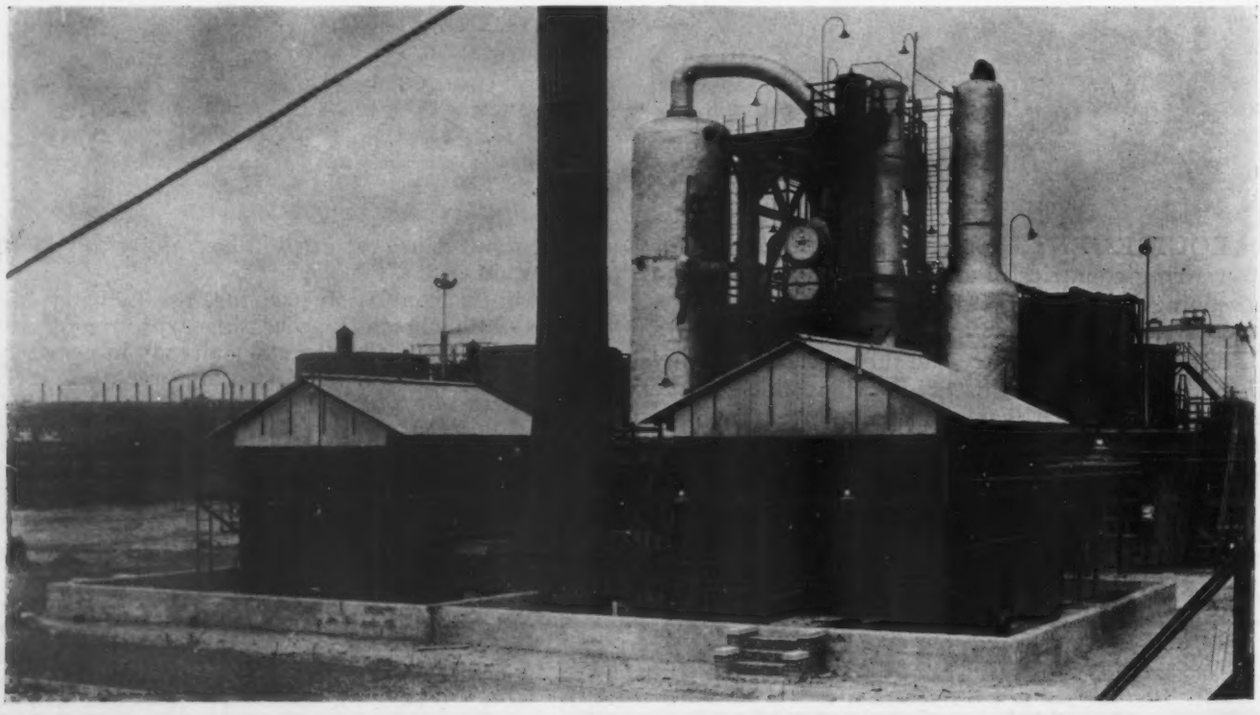
THE production of asphalt from heavy crudes presents particular problems. When asphalt is the main production requirement, a crude deficient in light ends and giving a large yield of asphalt is usually chosen. Such crudes are apt to contain considerable quantities of persistently retained salt water which will cause trouble by corrosion due to decomposition of the salt in the presence of water, or by deposition of salt on heating surfaces. The flow diagram on the opposite page illustrates the means applied to this particular problem in a plant designed and erected by E. B. Badger & Sons Co.

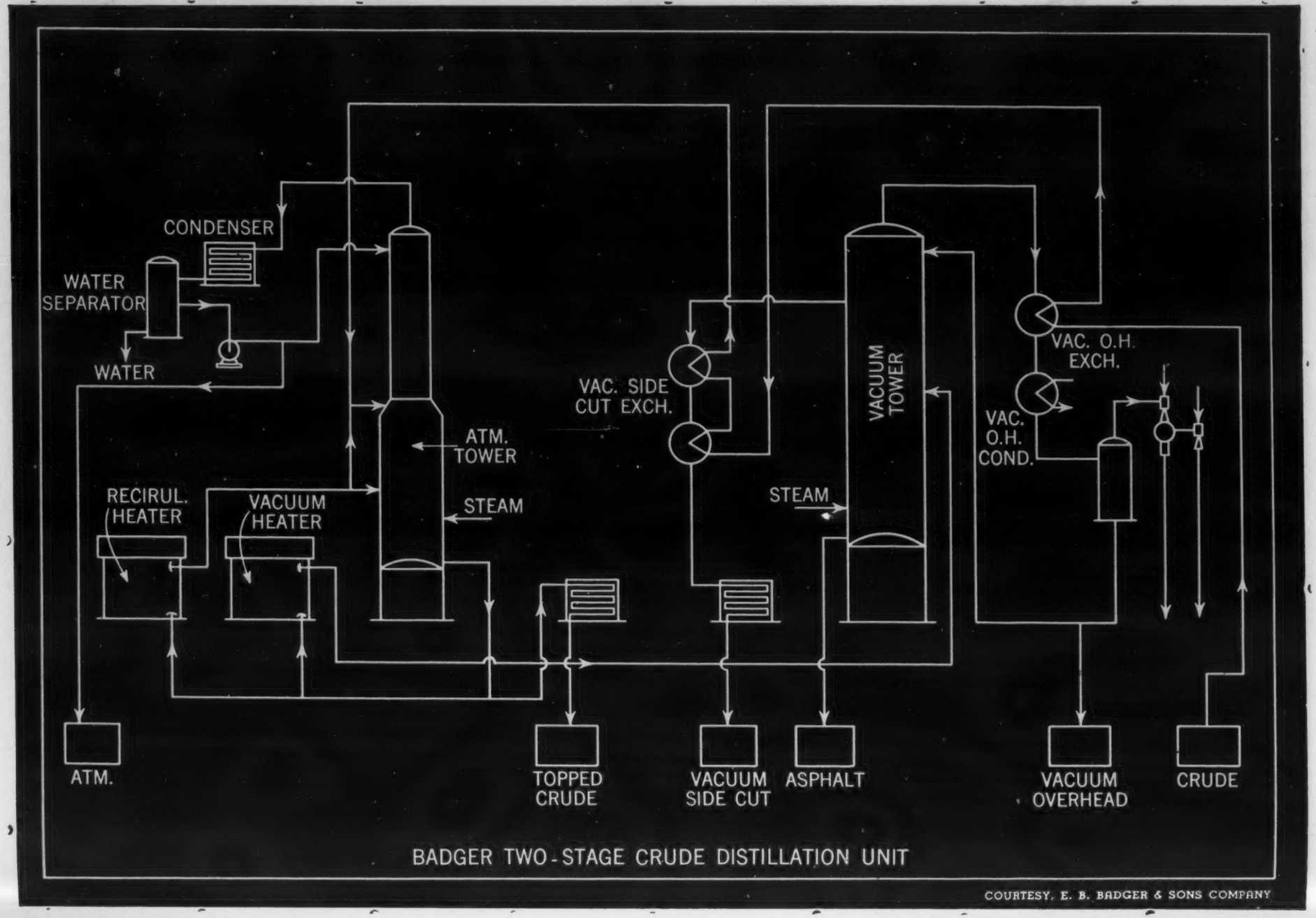
The heavy crude oil is pumped through exchangers on the vacuum side of the unit and is preheated to a point insufficient to vaporize the water in the crude at the existing pressure. Just before entering the atmospheric tower, the preheated crude is mixed with circulated reduced crude which has been heated in a pipe heater to a considerably higher temperature. This results in the vaporization of the water out of contact with any heating surface and in such a manner that the water and salt exist together at a high temperature only momentarily.

A part of the stream of circulated reduced crude is diverted into the lower part of the atmospheric tower for stripping or reboiling heat. Whether or not steam is added in the base of this tower will be determined by the nature of the crude and the products to be removed in this tower. The bottoms product from the atmospheric tower is the reduced crude, part of which is recirculated through the above mentioned heater, the remainder being passed through a second pipe heater, where it is heated to a somewhat higher temperature and discharged into the vacuum tower.

In this particular unit, only gasoline is removed in the atmospheric tower and a light gas oil or domestic fuel is the overhead product from the vacuum tower. A side product of heavy gas oil or cracking stock is also taken from the vacuum tower, and the remaining bottoms product is asphalt of a grade determined by the heater temperature and the quantity of side cut removed. The vacuum tower is operated almost as a dry vacuum system, at a relatively high vacuum in order to avoid damaging the asphalt product by high temperatures. A very small amount of steam is applied in the base of the vacuum tower to insure the absence of light ends from the asphalt. This system results in considerable simplification and increased effectiveness of the vacuum condensing system.

Operating units of this type produce asphalts of high quality and any desired penetration, and largely avoid troubles due to corrosion and salt deposition, even on crudes containing large quantities of sulfur and salty water.





BADGER TWO-STAGE CRUDE DISTILLATION UNIT

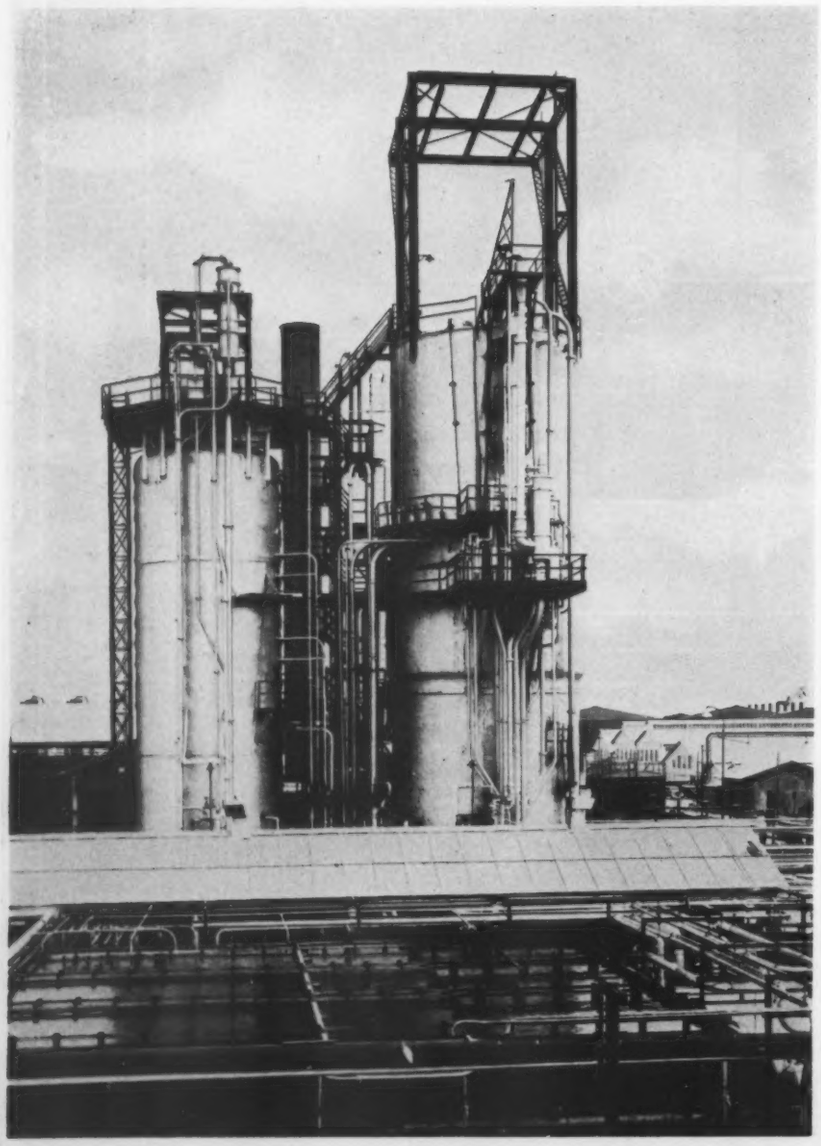
COURTESY, E. B. BADGER & SONS COMPANY

Two-Stage Vacuum Lube Distillation

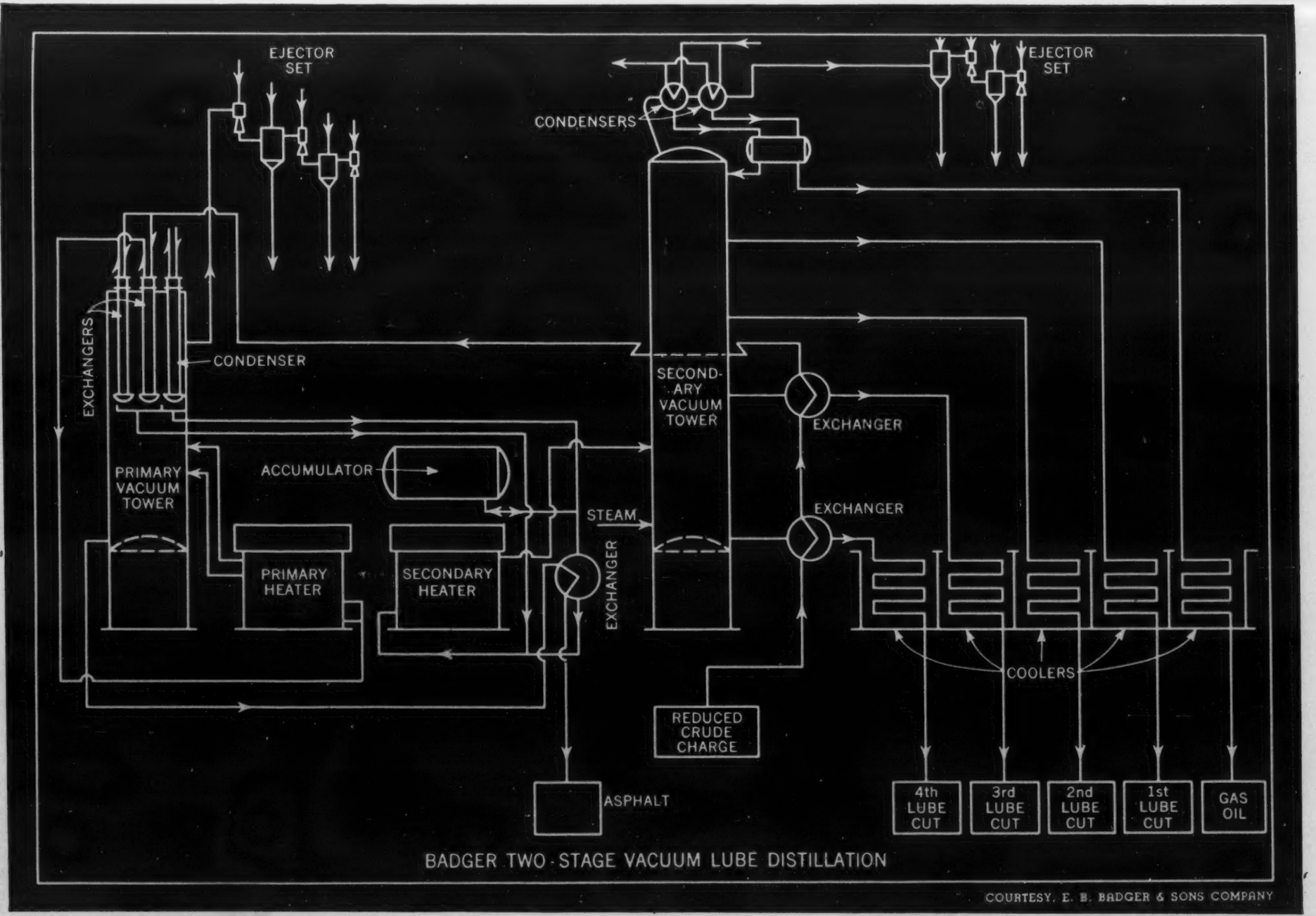
E. B. BADGER & SONS COMPANY

THE flow diagram on the opposite page illustrates a large unit which was built by E. B. Badger & Sons Company for the purpose of distilling lube stocks from heavy reduced crudes. The problem here was to vaporize the reduced crude down to an exceptionally heavy bottom and at the same time fractionate the total distillate into five well-separated cuts. In order to obtain the separations required, a considerable number of fractionating plates were necessary. If the whole operation were to be conducted in a single vacuum tower, the absolute pressure in the vaporizing zone would be such that very large quantities of steam would have to be added in order to obtain the required vaporization at permissible temperatures. This would result not only in a very large tower but in a very extensive condensing system and great difficulty in avoiding serious losses of oil carried as vapor with the steam into the vacuum equipment. In this particular case the use of large quantities of steam was also undesirable in itself.

This problem was solved by the use of two successive vacuum towers, each of them relatively moderate in size. In the first vacuum tower, the evaporation of the total distillate as one cut was accomplished at an absolute pressure of about 10 mms., without steam. No fractionating plates were used, and the vapors were condensed with as little sub-cooling as possible in order to conserve heat for the second vaporization. Two streams of this condensate were drawn off, and the cooler stream was preheated by exchange with the bottoms product before the streams were joined together for passage through the secondary heater. In the secondary vacuum tower, the vaporization took place at a pressure of about 60 mms. and a moderate temperature. The heaviest lube cut was stripped with a small amount of steam, and removed as a bottoms product, while the other fractions were separated by means of an adequate number of fractionating plates.



The overall results included very small total steam consumption, favorable fractionating and condensing systems, and a moderate fuel consumption due to the relatively low temperature required for the second vaporization, and the high recovery of latent heat together with slight subcooling of distillate in the primary distillation.



BADGER TWO-STAGE VACUUM LUBE DISTILLATION

COURTESY, E. B. BADGER & SONS COMPANY

Three-Stage Crude Distillation

E. B. BADGER & SONS COMPANY

ESPECIALLY in handling medium and light crudes, there are several advantages in removing a light gasoline cut in the manner indicated in the flow diagram, before proceeeding to the fractionation of the intermediate cuts. The water in the crude, as well as the gas and light ends, are kept out of the pipe heater and the main atmospheric tower and condensing system, thereby simplifying the design and operation of these elements. The evaporation of the water in the crude takes place out of contact with any heating surface; the salt contained in this water therefore remains in dispersed dry form in the oil, and is not deposited on the heating surfaces. The control of the separation between gas and light naphtha, and between the latter and heavy naphtha can be accomplished independently and therefore more effectively. Very low-boiling products can be obtained in the primary stage, without condensation of water in the tower, as no steam is required for stripping, this being accomplished by reboiling. Controlled amounts of the gaseous hydrocarbons can be kept in solution in this light cut, by operating under suitable pressures, whereas it is impracticable to do this in the main tower because of the temperatures required for vaporization of the kerosene and gas oil cuts.

The majority of the modern crude distillation units designed and built by E. B. Badger & Sons Company, ranging in capacity from 2,000 to 90,000 barrels per day, have been in conformance with the general scheme indicated in the diagram. (Compare also Badger Distillation Processes. Process Section, Refinery Catalog of 1939 and 1940.) In addition to differences in size, these units have been designed for a wide variety of crudes and required products, and conditions as regards economics and utility supplies have also varied widely; therefore considerable differences in design have been used, within the general scheme. The main variations in design are as follows:

The first stage has been designed for atmospheric operation in some cases, but more usually for pressures between 25 and 75 lbs. per square inch, gauge.

In the larger units, or in special cases, it becomes economical to provide two fired heaters, instead of the one shown in the diagram, for the first two stages. One heater circulates primary bottoms for reboiling, and the other serves only as a preheater for the secondary tower.

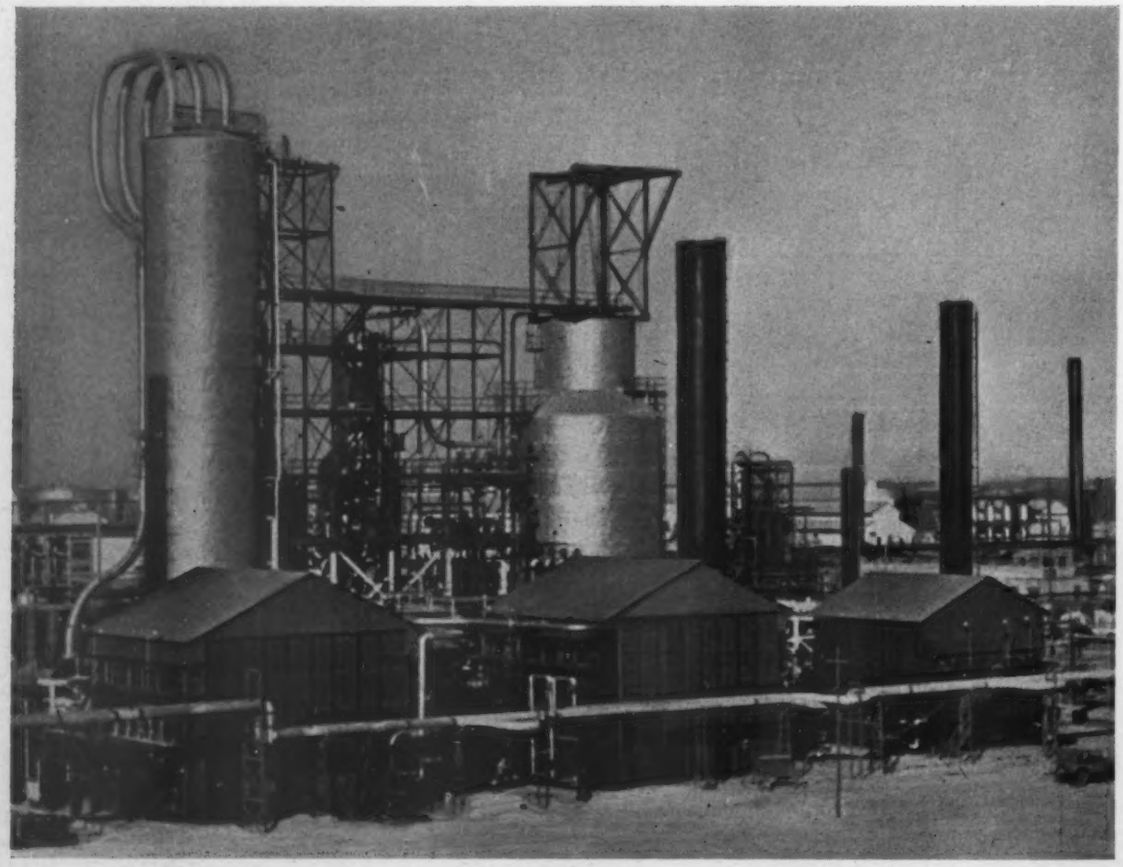
Condensers for the second stage have been of multi-tubular, submerged coil, or direct contact types, according to conditions.

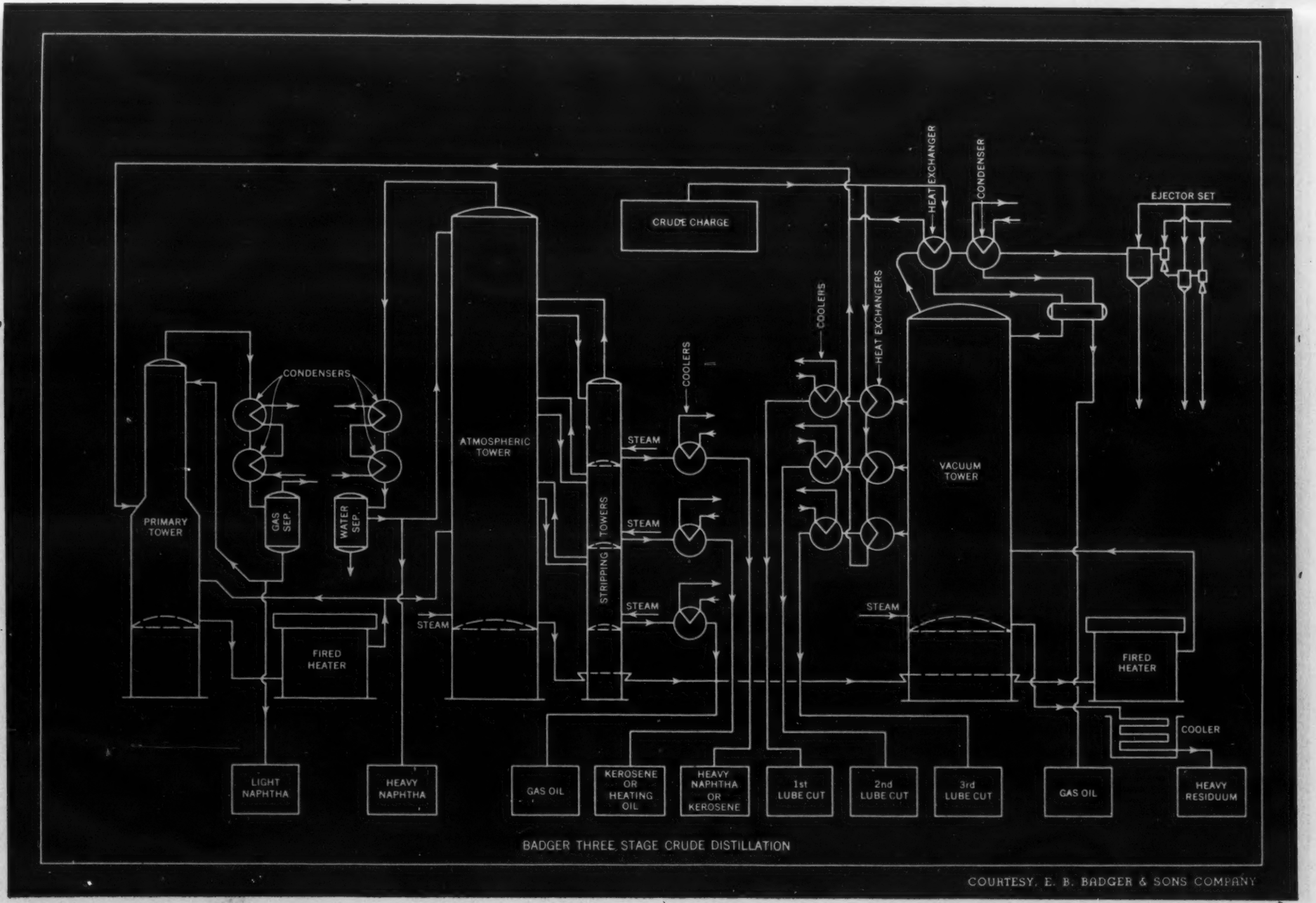
Vacuum Condensers have been multi-tubular and either placed within the tower or supported above it. In smaller units, where the vapor lines are of moderate size, condensers have been placed at a lower level for convenience.

Dry vacuum has been used, for its obvious advantages, where only one or two vacuum distillates were required, whereas it is usually preferable to use steam to assist in vaporization when several vacuum fractions are to be taken. (Compare Badger Two-Stage Vacuum Lube Distillation.)

Pumps have generally been used for removing the vacuum distillates from the system, but this has also been accomplished by a combination of steam lifts and barometric legs, and this is particularly preferable where pumps may be subject to severe corrosion by naphthenic acids in the distillates.

The heat exchange system has been different in nearly every unit and usually two alternative paths of flow are provided for different operations.





BADGER THREE STAGE CRUDE DISTILLATION

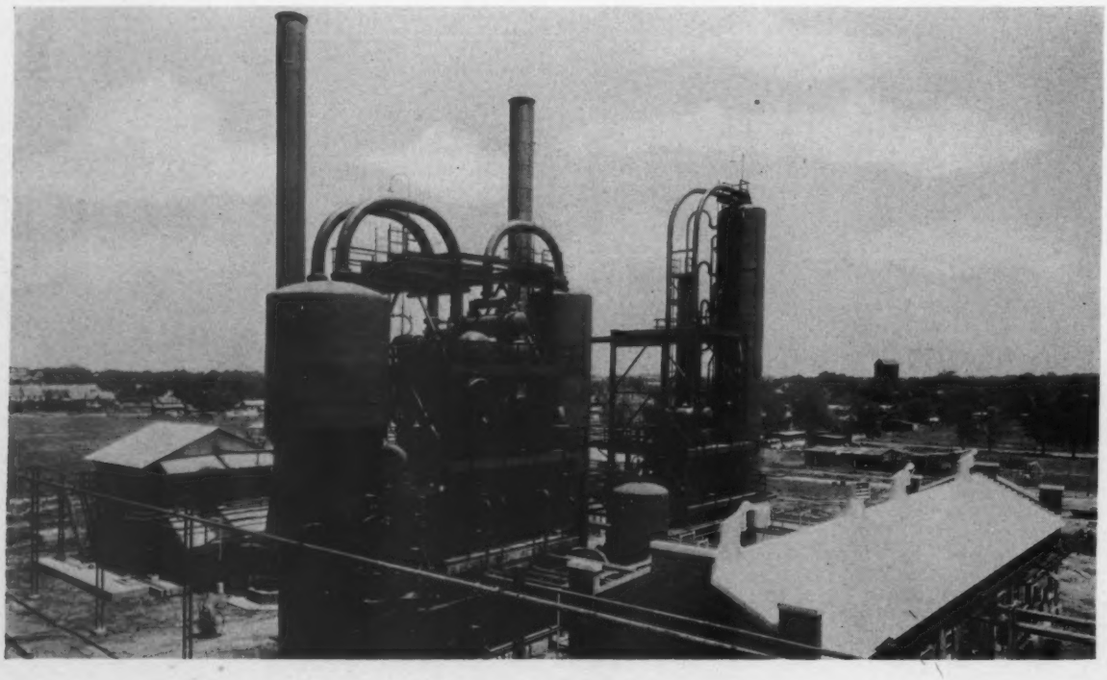
COURTESY, E. B. BADGER & SONS COMPANY

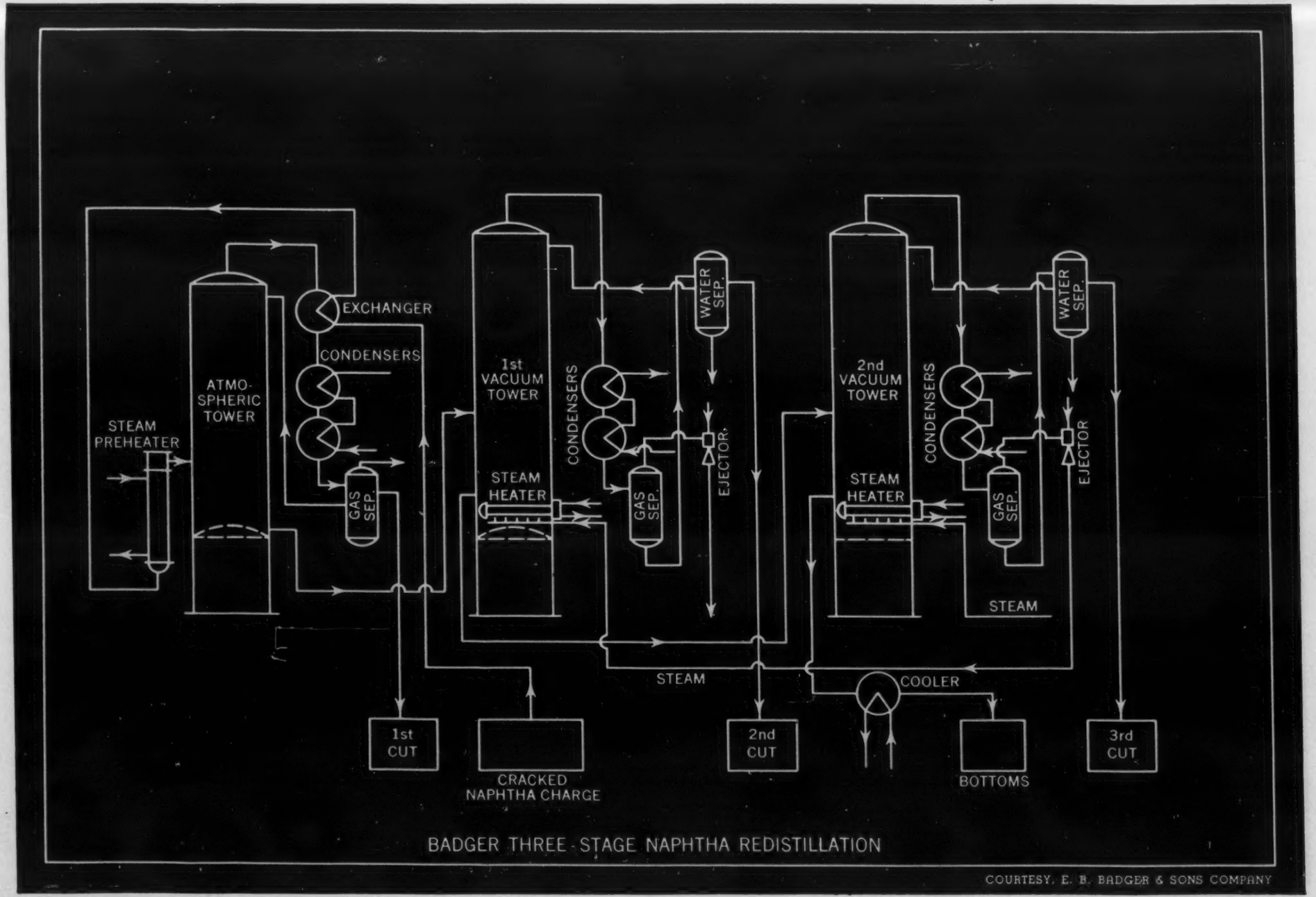
Three-Stage Naphtha Redistillation

E. B. BADGER & SONS COMPANY

THE redistillation of acid treated cracked distillates at atmospheric pressure has frequently been found to give products which are lacking in stability with regard to color and gum formation; and these results have been attributed largely to thermal decomposition of certain compounds present in the treated cracked distillate, including sulphonated hydrocarbons. This thermal decomposition is also accompanied by the formation of sulphur dioxide which causes corrosion of the equipment. It has been found possible to reduce this thermal decomposition with its harmful results to a practical minimum, by distilling the heavier components under reduced pressure and thereby lowering the maximum temperature of the operation. The particular temperature limitation set in a given case will depend upon the composition of the charging stock and the particular quality required in the product. A considerable number of units have been built on this principle and have been designed for maximum temperatures varying from 250° to 300° F.

Two units, each to rerun 10,000 barrels per day of cracked distillate, have recently been furnished by E. B. Badger & Sons Company in accordance with the design indicated in the flow diagram on the opposite page. This shows a three-stage distillation, of which the second and third stages are under vacuum; and the maximum distillation temperature is 260° F. Approximately this temperature is reached in all three stages, the vaporization taking place in the second stage at about 250 mm. absolute pressure and in the third stage at about 85 mm. Only a small percentage of the total distillate is vaporized in the third stage, but if the third stage were not used, the second stage would have to be operated at a much lower absolute pressure and a considerable penalty in equipment size and steam consumption would result. This system has the further advantage of producing three cuts of different and adjustable boiling ranges, but even if the total overhead is desired as one cut only, the system has the advantage of low steam consumption.





BADGER THREE-STAGE NAPHTHA REDISTILLATION

COURTESY, E. B. BADGER & SONS COMPANY

The Brugma Process

THE Brugma Process offers a means for the fractional distillation of a charging stock and production of four or more products in less than the conventional number of fractionating and stripping sections. In the conventional application of distillation equipment the number of columns required equals the number of products to be recovered, less one. This principle holds good whether there are only two products from each column or whether side stream strippers are used, and a number of products removed from the main column.

The Brugma Process is essentially different in that it provides a means of obtaining an increased number of yields, i.e., four products from two columns; five to eight products from three columns. In this way the installation of a Brugma Process results in an important saving in ground space required, as well as effecting a material economy in the cost of operating a close fractionating unit.

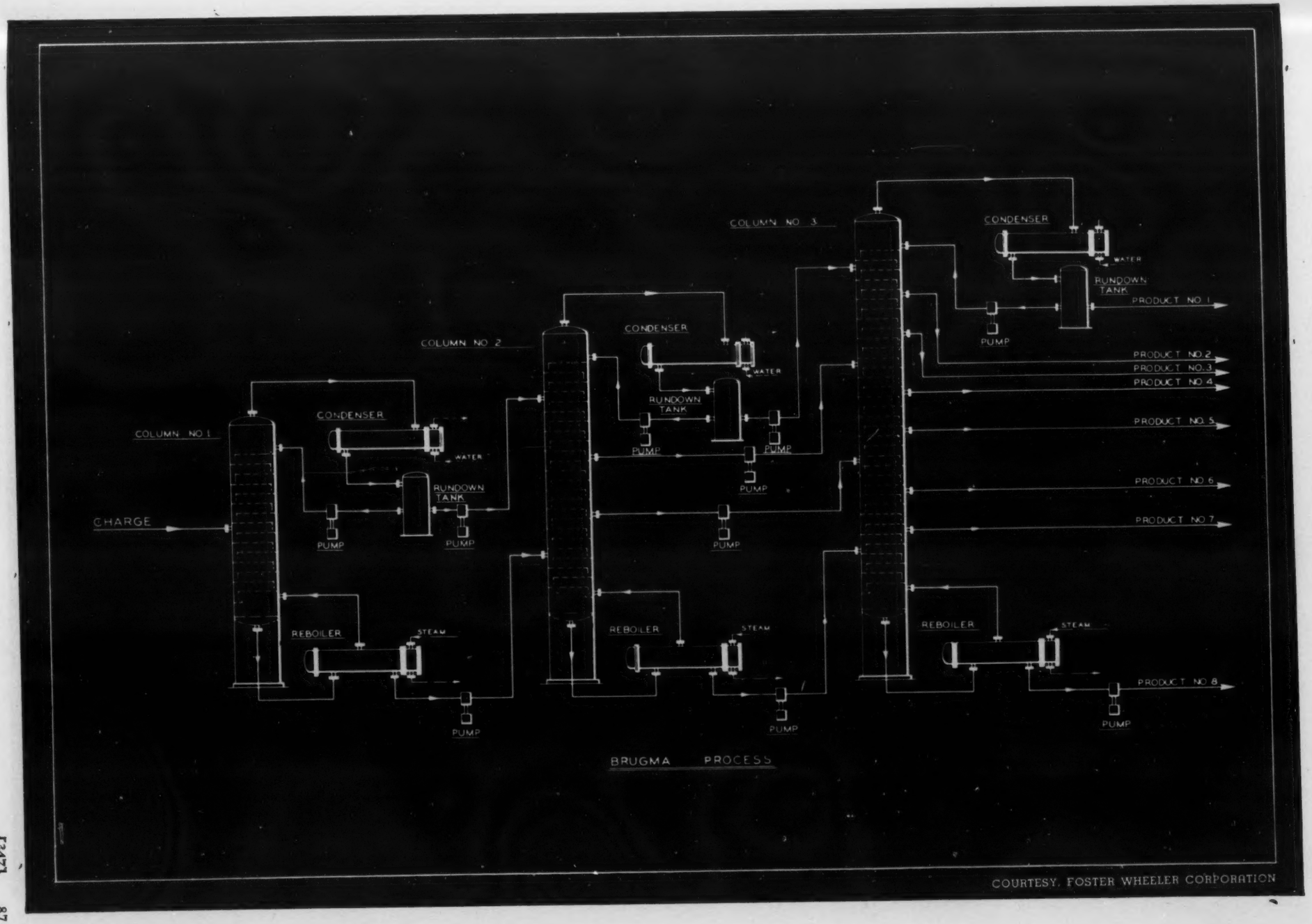
There is shown on the opposite page a typical flow diagram of a Brugma application designed to return eight products from three towers. The first tower of the plant, shown at the left as column 1, is purely conventional in construction and operation; it receives the charge (which may or may not be preheated, depending upon the desired basis for operation) and splitting it into two closely fractionated products. The overhead stream from this first tower is fed into the upper portion of the second tower (referred to in the flow diagram as column 2) where it is in turn split into two closely fractionated products. Likewise, the bottom stream from the first tower is fed into the lower portion of the second tower and split into two closely fractionated products.

The operation of that portion of column 2, above the upper side stream, is entirely conventional, as is also the operation of the lower portion of the tower—below the lower side stream. That section of the column between the two side streams operates to maintain the fractionation between these two streams, and makes possible the direct interchange of heat between the lower and the upper portion of the tower. By this arrangement the reflux from the upper portion of the column serves as condensing medium to provide reflux for the lower portion and the vapors from the lower portion provide heat to reboil the reflux from the upper portion. This action eliminates the necessity for one reboiler and one condenser, as compared to a fractionating unit of conventional design.

Following this procedure through a third column, it is possible to develop eight final products. In other words, each of the four streams from the second column is fed into the proper intermediate point of column 3, and two final products are withdrawn from the column between each pair of feed streams; in addition there are, of course, products from the column tops and bottoms. Through the application of this system, it is thus practicable to eliminate three condensers and three reboilers through using the third column.

The same principle may be used for recovering any number of products from four upward and similar advantages will accrue through the saving in equipment and operating expense. An indication of the economic advantage of the Brugma Process, so far as the costs of heating and of cooling water are concerned, may be appreciated from the fact that the total overhead product from the three columns is only about 60 percent of that which would be present when operating a seven column unit of usual design.

This description of the Brugma distillation process is presented through the courtesy of Foster Wheeler Corporation, 165 Broadway, New York City, which has been granted the exclusive right to manufacture, use and sell apparatus for effectuating the process.



COURTESY, FOSTER WHEELER CORPORATION

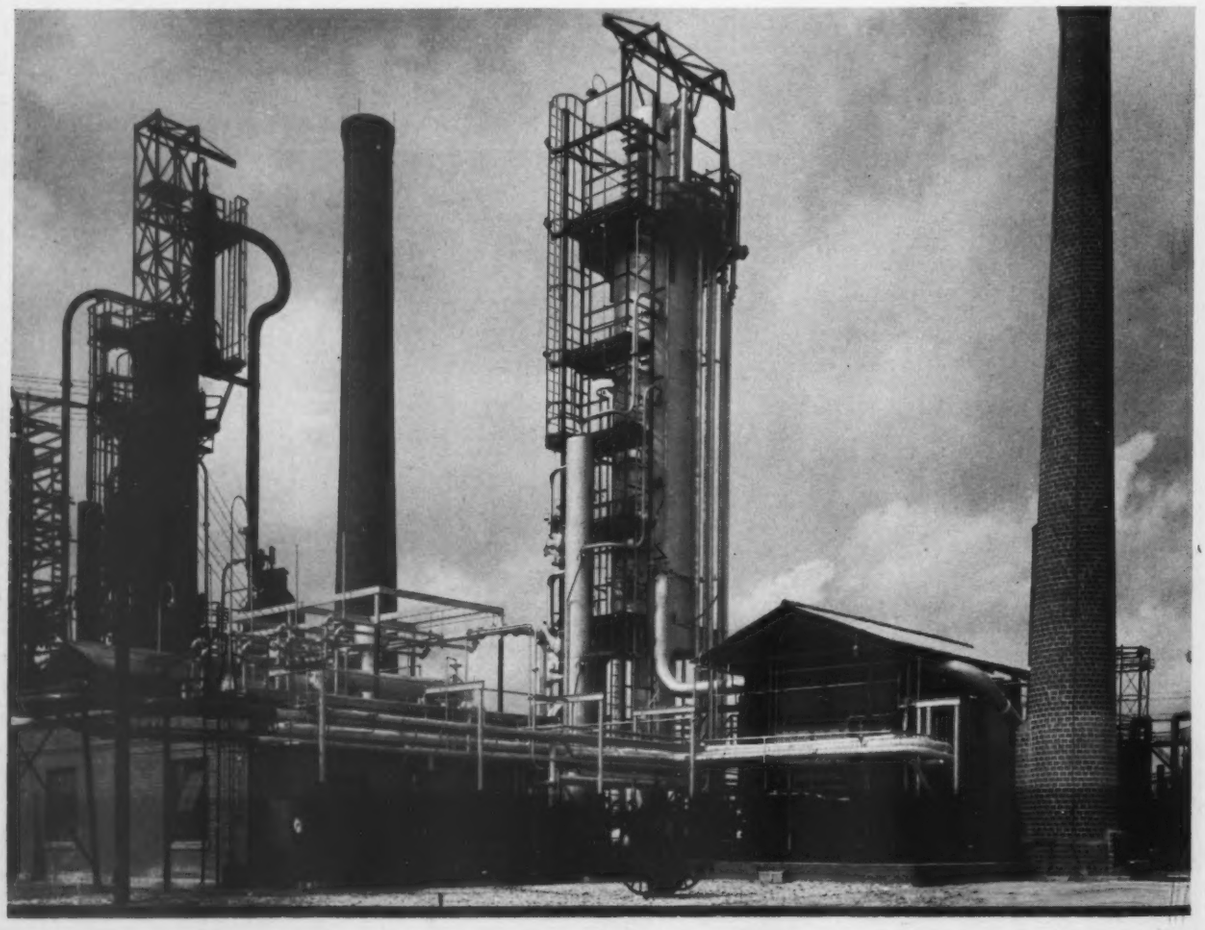
Carrier Distillation Process

IN THE production of lubricating oils from various base crudes, many cases arise in which it is desirable to prepare the most viscous stocks from overhead distillates. Such a procedure eliminates the necessity of deasphalting or deresining the reduced crude by means of sulfuric acid or precipitative solvents. To carry out such an operation The Lummus Company of 420 Lexington Avenue, New York, has developed the Lummus Carrier Distillation Process. This process has been placed in operation in several commercial units.

The accompanying diagram illustrates one of the numerous possible applications of the Carrier Distillation principle. Crude is first reduced in conventional equipment for the removal of the maximum amount of raw lube distillates. This reduction is carried to the point where an attempt to obtain more viscous distillates would degrade such stocks because of the cracking encountered at the excessive temperatures required. The reduced crude is then mixed with preheated Carrier distillate, passed through the heater and flashed into a vacuum tower. The carrier may be kerosene, light gas oil or any such type of material ordinarily found in a refinery and having a suitable boiling range. Its function is to reduce the effective pressure under which vaporization of the viscous lube distillate proceeds, consequently the maximum temperature required is brought down to a point where the cracking rate is negligible. In the vacuum tower, the bottoms are shown as being steam stripped for the complete removal of viscous lubricants while the desired lube distillate is withdrawn as a side stream and separately stripped. In certain operations, steam stripping may be completely eliminated on both bottom and side cuts without sacrifice of fractionation or flash. The carrier is taken overhead, condensed and recycled continuously.

The use of a carrier results in (1) the reclamation of heat in the overhead condenser which is ordinarily rejected as steam to the barometric condensers in conventional wet vacuum systems, (2) reduced size of vacuum equipment because of a reduced jet load, (3) reduced peak temperatures within the heater because of vacuum penetration well back from the outlet.

The internal type of condenser bundles employed result in reduced pressure drops and make for a compact, easily accessible, economical type of construction.



LUMMUS CARRIER DISTILLATION PROCESS
COURTESY, THE LUMMUS COMPANY
CARRIER
WATER
STEAM
EXTRA HEAVY LUBE DISTILLATE
BOTTOMS
SUPHTD STEAM
WATER
CARRIER
REDUCED CRUDE

Catalytic Alkylation Process

THE Catalytic Alkylation Process has enabled the petroleum industry to produce from large quantities of refinery gas formerly discarded or used as fuel, a product, which today forms the basis for most of the 100 octane aviation gasoline.

Fundamentally, alkylation is the joining of an isoparaffinic with an olefinic hydrocarbon. The process as commercially practiced today uses isobutane and butylenes as the isoparaffin and the olefin respectively and the chemical reaction which is catalyzed by strong sulphuric acid results in a high octane saturated product exhibiting excellent blending and leading qualities.

The simplicity of the process is evident from the diagrammatic flowsheet shown on the opposite page and except for the acid contacting section of the plant its operation presents no refining techniques or problems other than those normally encountered in modern distillation and fractionation equipment.

Fresh feed entering the plant is first joined by recycled isobutane so that the combined stream entering the contact tank will contain the proper isoparaffin-olefin ratio, necessary for the most efficient catalytic reaction and for the production of a high octane alkylate. It is essential that thorough agitation of the acid-hydrocarbon mixture be maintained in this tank or reactor during the contact period. One of the several means by which this can be accomplished is shown on the attached flowsheet, and consists of a circulating pump which takes suction from the contact tank, discharging into the total feed line, before the entire mixture enters the tank and is pumped through orifices or jets.

Alkylation reactions are exothermic and therefore cooling of the reactants must be provided in order to prevent excess temperature rise in the zone of contact. Although not shown on the flowsheet, this cooling may be accomplished by several suitable methods, one of which involves circulating a portion of the agitator pump discharge through a refrigerating medium.

Leaving the reactor, the hydrocarbon product and acid mixture first enter an acid settler, where essentially all the acid is separated from the oil and returned to the reaction zone. The last traces of acid are then removed from the oil in the caustic washing step, consisting of a conventional mixer, settler and circulating pump, so that corrosion problems in the subsequent fractionation and distillation operations will not be encountered.

The iso-butane fractionator to which the hydrocarbon stream is sent after leaving the caustic settler separates overhead, from the total alkylate product and unreacted butane, the excess iso-butane for recycling to the reaction zone. The bottoms from this tower are subsequently sent to the debutanizer tower where pure normal butane which may be sold as such or used for blending purposes is taken overhead, the total alkylate product being withdrawn as a bottom product. Final separation of total alkylate into a small quantity of heavy alkylate designated as "Bottoms" on the flowsheet and aviation endpoint blending stock is made in the rerun tower. This rerun tower, entirely conventional in design, is exceptionally flexible and as a result may be operated to obtain any desired split between its bottom and top products.

Not shown on the flowsheet is a small fresh acid pump which discharges into the reactor to maintain proper reaction conditions. Spent acid, which in commercial practice has proved especially successful in the treatment of naphthas, furnace and lubricating oils, is withdrawn from the acid settler.

Below are presented in tabular form typical inspections of feed stocks and products together with pertinent blending data.

TABLE I
Typical Alkylation Feed Stock

	Liquid Vol. Percent
Propane	5.3
Isobutane	27.5
Butylenes	23.9
Normal Butane	42.4
Pentanes and heavier	0.9
	100.0

TABLE II
Typical Inspections

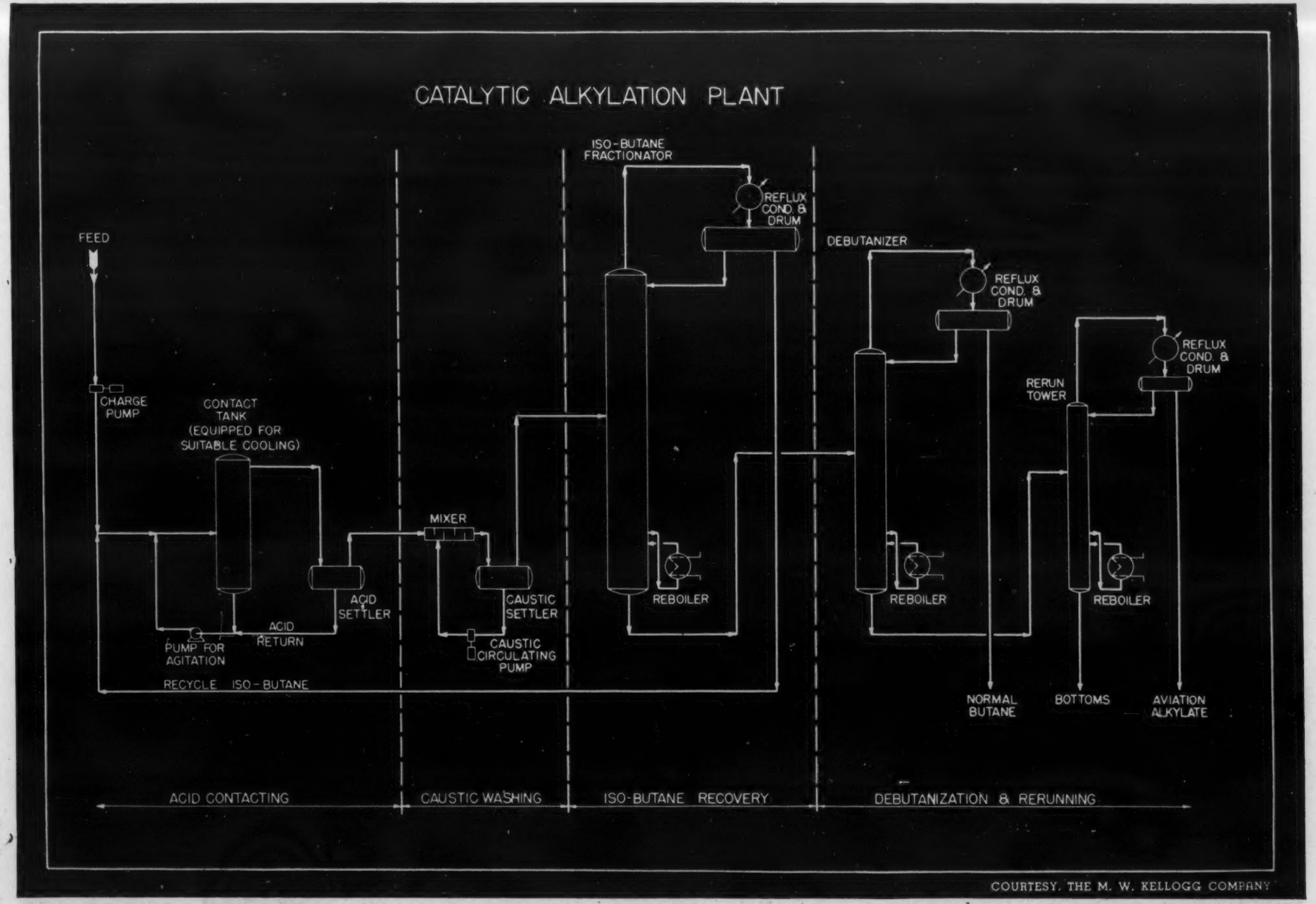
	Total Alkylate	Aviation Cut	Bottoms
°A.P.I.	70.6	71.1	50
I.B.P.	127	130	348
10 Percent	181	182	368
30 Percent	212	208	...
50 Percent	226	221	402
70 Percent	239	228	...
90 Percent	305	237	496
F.B.P.	421	266	550
Vapor Pressure	.....	4.1	...
Octane No. (ASTM)	94.0	95.0	84
Vol. Percent of Total Alkylate	100	91	9

TABLE III
Blend of Typical Alkylate

Percent Virgin Gasoline	100	...	35
Percent Alkylate	...	100	65
°A.P.I.	64.8	68.5	67.0
ASTM Distillation, °F.:			
I.B.P.	118	140	120
10 Percent	161	206	186
30 Percent	185	218	206
50 Percent	208	223	219
70 Percent	228	228	227
90 Percent	257	240	244
E.P.	296	330	312
R.V.P.—Lbs./Sq. In.	4.8	2.4	3.5
Octane Number, CFR-M, Clear	62.0	94.0	83.6
Octane Number, CFR-R+3 ccPb	81.5	...	96.4
Corrosion (Copper Strip)	Pass	Pass	Pass
Sulfur	.01	.009	.01
Gum (Copper Dish)	Negilgible	1.0	1.0
Color	+30	+30	+30

Although catalytic alkylation has been commercially proved as evidenced by units which have been in operation for several years, the process has received its chief impetus just recently as a result of its ability to produce economically and efficiently a premium aviation product.

Licenses for the process are available through The M. W. Kellogg Company.



COURTESY, THE M. W. KELLOGG COMPANY

Distillate Recovery

RECYCLING AND REPRESSURING

AMONG the more important developments in recent years in the art of petroleum production are the so-called recycling and repressuring operations. Generally speaking, both these operations involve the extraction of the heavier petroleum fractions from gas, followed by compression of the denuded gas in order to return this gas to oil producing sands. More specifically, and by way of differentiation, recycling refers to the production of a high pressure gas from which the heavier constituents are removed, the stripped gas being compressed and returned to the same reservoir from which the original high pressure gas was produced. In repressuring operations the stripped gas is returned to a reservoir other than that from which the original gas was produced.

Fundamentally, the purpose of recycling and repressuring operations is to conserve gas supplies and at the same time permit the recovery of condensate or distillate which might otherwise be lost by other production methods in which pressure is not maintained on the reservoir. Ordinarily in such operations, the only quantity of gas consumed is that required for utilities in the operation of the plant, the rest of the gas being returned to the reservoir.

The quantity of distillate or condensate obtained from recycling and repressuring operations varies widely. In order to evaluate economically the merits of a contemplated recycling installation, it is necessary to have accurate test data on the gas-oil ratio for the proposed well with full analyses and inspections of the gas and condensate. The M. W. Kellogg Company has recently put into service a motorized portable testing unit with complete facilities for obtaining these data. The services of the process-engineering staff of The M. W. Kellogg Company are available for analyzing these data and working out the most economical installation.

The flowsheet on the adjoining page illustrates a typical combination recycling and repressuring operation. Low pressure (e.g. 0-50 lb./sq. in.) casinghead feedstock is compressed to an intermediate pressure (e.g. 100-250 lbs.) and charged to the low pressure absorber tower in which the heavy end of the distillate or condensate is used as absorption oil. Casinghead gasoline plus the desired quantities of propane and butane are condensed by contact with the absorption oil. For high recoveries of propane and butane, the lean oil is chilled as indicated by a refrigeration cooler using a conventional propane or butane refrigeration system. Part of the dry gas from the absorber tower is bled off to the fuel line to satisfy utility requirements for the total unit. The balance of the dry gas is recompressed in stages and returned to the input wells for pressure maintenance.

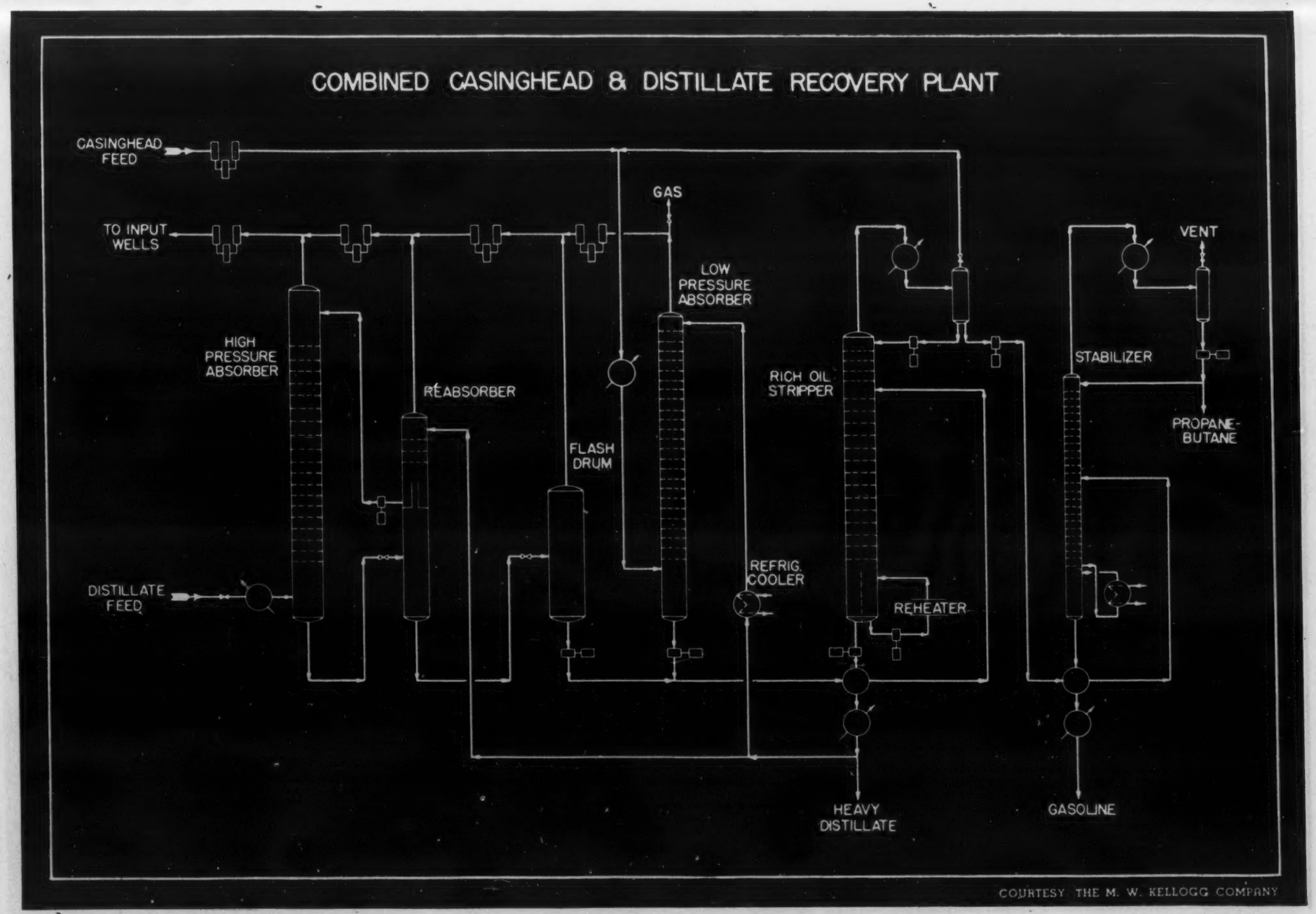
The distillate gas is charged directly to a high pressure absorber (e.g. 700-2500 lb.) in which recycle heavy distillate is used as absorption oil. Before entering the absorber, the pressure is partially released and the gas is cooled to a temperature approaching that of the cooling water. This drop in pressure results in partial condensation of liquid resulting from the retrograde condensation phenomenon. Likewise the lower absorber pressure reduces the absorption oil rates required for the desired recovery of distillate. This apparent contradiction of vapor-liquid equilibrium as commonly known and practiced in pressure regions below the critical, is again the result of retrograde condensation. The pressure to which the gas is dropped is determined by an economic balance on the cost of the recycling compressors vs. the cost of the absorption recovery equipment.

The rich oil from the base of the high pressure absorber is successively flashed in stages at lower pressures to release the undesired volatile light constituents such as methane and ethane. The number of flash stages is usually a function of the operating pressure of the high pressure absorber, the higher the pressure the greater the number of stages. Liquid from the final flash drum is combined with the rich oil from the low pressure absorber and charged to a rich oil stripper where the absorber oil is withdrawn from the bottom, and any excess is sent to storage as heavy distillate product. The overhead from the stripper is partially condensed and the uncondensed vapors are recycled to the low pressure absorber. The condensed liquid is charged to a stabilizer tower for the production of a stabilized gasoline and an overhead liquid product rich in propane and butane, which may be further processed for the production of additional quantities of motor fuel or aviation gasoline.

The properties of the distillate vary appreciably. Gravities are known to range from less than 35° to higher than 70° API but are preponderantly in the range 55-60. The following tabulation indicates properties of a particular distillate:

	Stabilized Distillate	Debutanized 300 EP Gasoline	Debutanized 400 EP Gasoline
Percent of Total	....	50.1	69.7
Gravity	59.6	69.2	64.0
CFR-M Octane Clear	....	60.1	50.6
CFR-R Octane Clear	....	61.0	51.5
CFR-M Octane + 1 cc lead	....	73.9	65.0
CFR-M Octane + 3 cc lead	....	84.5	78.3
I.B.P.—°F.	100	100	100
10 Percent	149	140	147
30 Percent	220	174	196
50 Percent	280	200	237
70 Percent	380	226	282
90 Percent	552	259	341
EP	670	300	400

As indicated in the above tabulation, the gasoline fractions normally have a high lead response and accordingly may be used directly for blending. The economics for processing the distillate, especially the heavier fractions, together with the recovered liquid propane and butane fractions, indicate a highly favorable return on investment for the production of premium motor fuels together with the production of large amounts of 100 octane aviation fuel.


COMBINED CASINGHEAD & DISTILLATE RECOVERY PLANT
CASINGHEAD FEED
TO INPUT WELLS
GAS
LOW PRESSURE ABSORBER
HIGH PRESSURE ABSORBER
REABSORBER
FLASH DRUM
RICH OIL STRIPPER
VENT
STABILIZER
PROPANE-BUTANE
DISTILLATE FEED
REFRIG. COOLER
REHEATER
HEAVY DISTILLATE
GASOLINE
COURTESY THE M. W. KELLOGG COMPANY

Dubbs Cracking Process

UNIVERSAL OIL PRODUCTS COMPANY, Chicago, licenses and designs cracking units for various types of operations, producing maximum yield of anti-knock end-point gasoline and at the same time specification fuel oil or high-grade coke from a wide variety of charging stocks.

The accompanying process chart and photograph show one of the latest Dubbs units. This type of two-coil selective cracking unit has produced optimum results when processing a wide variety of residual stocks. With the development of the equiflux heater and its incorporation into the two-coil selective plant, it is possible to obtain temperatures as high as 920° F. in the middle of the reaction chamber. With the reaction chamber operation at this temperature level, the heavy charge is subjected to a far greater time-temperature action than can possibly be achieved without the use of the reaction chamber as a means of viscosity-breaking. As a result yields are improved and at the same time plant costs are reduced, due to the greatly increased cracking rates obtained at high temperatures.

When operating to produce only gasoline and fuel oil of 220 S.F.S. viscosity, this unit has produced from 25° A.P.I. Mid-Continent reduced crude, 53.5 percent of gasoline of 69-70 octane rating, 37.5 percent fuel oil of 200 S.F.S. at 122° F., and .7° A.P.I. gravity, 5 percent of catalytic polymer gasoline of 10 Reid vapor pressure, or a total gasoline, including polymer, of 58.5 percent of 71-72 octane rating. This operation can be varied at will to produce more fuel oil, including burner oil and less gasoline or coke instead of fuel oil.

Important developments in the Dubbs process facilitate the handling of the heavy oils or residues. Among these are improved special coking methods, known as external coking, integral coking and precoking, as well as improved methods of coke removal and handling, notably an hydraulic system.

The end-point gasoline produced from the cracking unit requires no clay or sulphuric-acid treating, but merely sweetening. It should be inhibited to prevent gum formation by U.O.P. inhibitor No. 1 or No. 4, likewise developed by Universal Oil Products Company.

One mode of operating the Dubbs cracking process is to pump the raw oil into the fractionating tower, where condensation of the heavier vapors takes place.

The mixture of heavy condensate and raw charging stock is pumped through one heating coil, wherein it is subjected to elevated temperature and pressure, thence passing into a reaction chamber.

A lighter fraction is withdrawn from the side of the fractionating tower by means of a hot oil pump, which discharges said oil through a heat exchanger and thence to a second heating coil, wherein the side-cut is subjected to higher temperature and pressure conditions than is maintained within the first bank of heating tubes.

The side-cut oil discharges into the same reaction chamber as the other heated oil. The hydrocarbon mixture from the reaction chamber is discharged from the bottom thereof and flows into a flash chamber at reduced pressure, where a segregation into vapors and liquid residuum takes place.

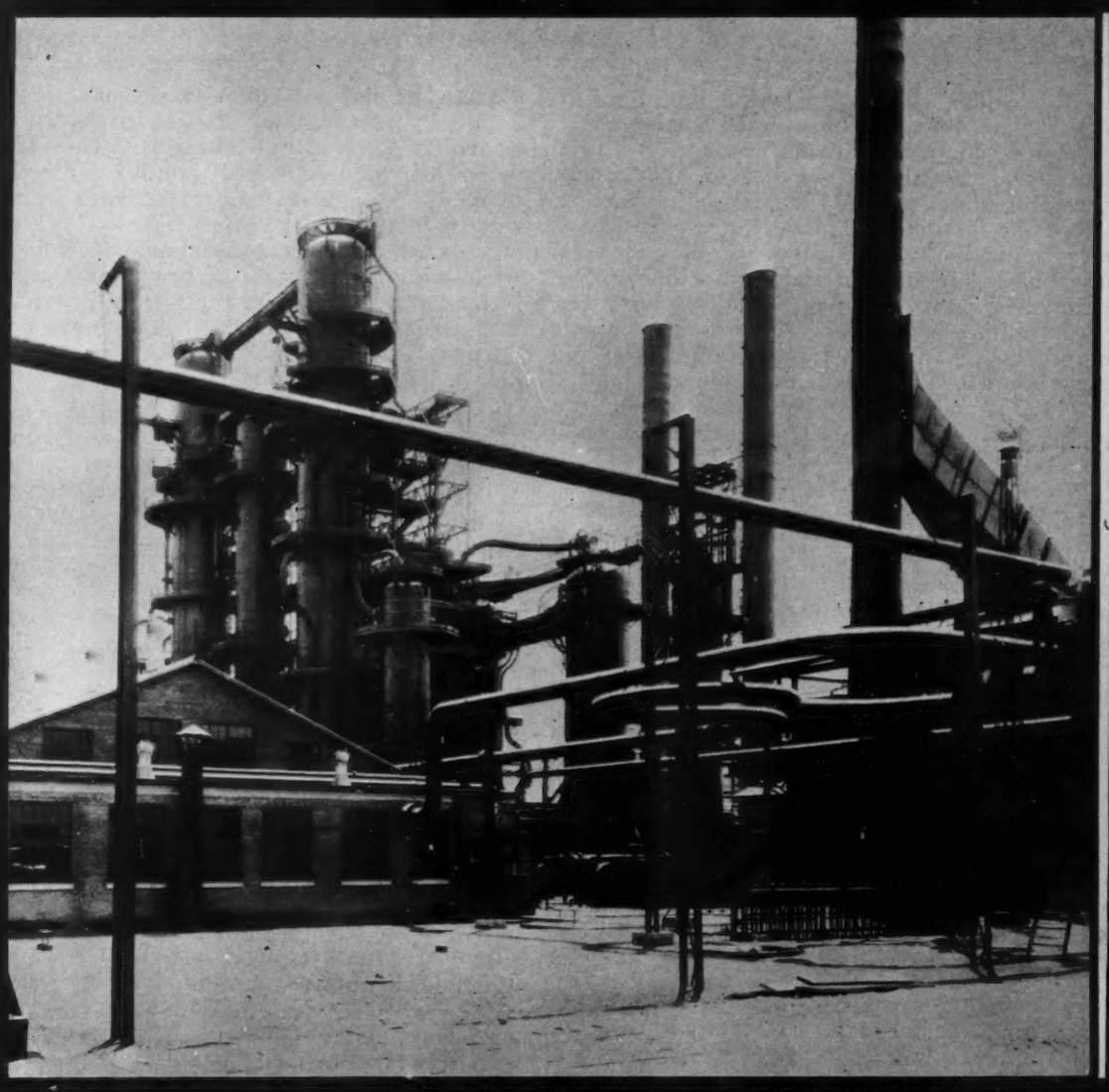
The hot vapors pass into a heat exchanger and thence to the fractionating tower, where separation into gasoline, light oil fractions and heavier reflux condensate takes place. The gasoline passes from the top of the fractionating tower to a water condenser, where it is liquefied, and then passes to a distillate receiver and to a stabilizer, whence it is finally discharged to storage. A furnace distillate may be taken from a point in the fractionating column intermediate between the top of the column and the point where light reflux condensate is removed.

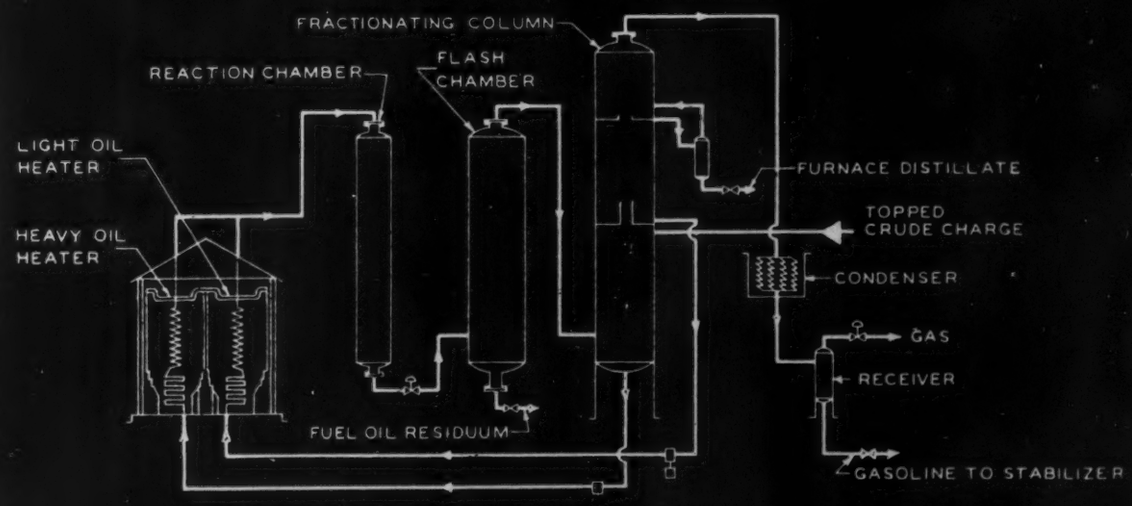
The incondensable gas, which is discharged from the top of the distillate receiver and from the stabilizer, is utilized mostly for fuel, although it is used for enriching city gas and a limited amount is used as raw material for chemical synthesis.

The cracked gas may be treated by means of the U.O.P. catalytic polymerization process to produce polymer gasoline of 81 octane number or higher and a blending value up to 125, depending upon the gasoline to which it is added.

The hot residual oil from the flash chamber may be cooled and passed to storage and marketed as fuel oil or, if desired, it may be directed into the alternately-operated coking chambers.

Auxiliaries of the Dubbs cracking unit consist of a number of highly scientific control and regulating instruments, most of which are of the recording type. These regulating devices control temperatures, pressures, flow of oil, liquid levels, pumps, etc. The equipment includes pumps for handling hot and cold oil, light and heavy distillates and cooling water.





TWO COIL SELECTIVE DUBBS CRACKING UNIT

COURTESY, UNIVERSAL OIL PRODUCTS COMPANY

The Edeleanu Process

THE Edeleanu Process, employing liquid sulfur dioxide as a solvent, has been used commercially since 1911 for refining petroleum products. Its first application was for the production of high grade kerosenes from highly aromatic and sulfur-bearing crude kerosene distillates. This advance over heavy acid treatments with their attendant high loss of hydrocarbons led to its eventual application on the entire range of petroleum products. The Edeleanu Process is unique insofar as it is the only solvent refining process by which all fractions of mineral oils may be extracted. The low boiling point of sulfur dioxide (14° F.) makes the problem of recovering the solvent relatively simple even though hydrocarbons in the gasoline boiling range are present.

The flow diagram on the opposite page, presented through the cooperation of E. B. Badger & Sons Company, 75 Pitts Street, Boston, Mass., shows a plant suitable for the treatment of light naphthas, special fractions for solvents and sprays, high octane aviation gasoline blending stocks, kerosenes, high cetane diesel oils, transformer oils, and light lubricating oils. A plant for the treatment of naphthas alone would not require the vacuum pumps shown, as all the sulfur dioxide can be removed under atmospheric pressure. A study of the flow sheet shows that the plant consists of the following main sections:

(1) Counter-current extraction tower for contacting oil and solvent.
(2) Equipment for the recovery of the small amount of solvent which dissolves in the refined oil.
(3) Equipment for recovery of the bulk of the solvent which leaves the extraction equipment in the extract.
(4) Equipment for cooling oil and solvent, compressing, recondensing and dehydrating the solvent.

Conventional equipment is employed and a simple system for continuously dehydrating the liquid sulfur dioxide eliminates corrosion. With minor exceptions ordinary steel equipment is used throughout the plants. The best evidence of the efficiency of the water removal system is the fact that plants in operation for over fifteen years are still in excellent condition and operating at better than design throughputs.

The Action of Liquid Sulfur Dioxide

Liquid sulfur dioxide preferentially dissolves aromatic hydrocarbons. It has a less definite preference for naphthenic hydrocarbons and little solubility for paraffines. The degree to which naphthenes and paraffines are dissolved depends upon the temperature of extraction and the boiling range of the stock being treated. The lower the extraction temperature, the less paraffines and naphthenes will be dissolved. The lower the boiling range of the material being extracted, the greater will be the solubility of paraffines and naphthenes dissolved. Generally, therefore, lower boiling materials are treated at lower temperatures than higher boiling ones. Various modifications of the process make it possible to vary the solvent power of SO_2. One of these is the use of benzol in mixture with SO_2. As benzol is added to the sulfur dioxide, its ability to dissolve the naphthenic hydrocarbons and paraffinic hydrocarbons is increased. Benzol SO_2 mixtures containing larger proportions of benzol will dissolve all liquid hydrocarbons at a temperature of 0° F. to the exclusion of wax. This solvent mixture is therefore used for both extraction and dewaxing. The material may first be dewaxed with a high proportion of benzol in the solvent at lower temperatures and the filtrate immediately solvent refined with a solvent containing a higher proportion of SO_2.

Naphtha

Liquid SO_2 is commercially used at temperatures varying between +10° F. and —60° F. to separate aromatics from naphthas. The extracted material, which will vary from 50 to 90% aromatics, will have octane numbers varying from 75 to 90 and Kauri Gum numbers of from 75 to 90 respectively. The yield of extract will be determined by the amount of aromatics in the stock to be extracted. Generally speaking, in the case of straight run stocks, the quality of the extract will be about the same regardless of the source of the stock charged. The paraffinic portions of these naphthas (raffinates) will be practically free of aromatics and are frequently sold as special solvents (VM&P naphthas, Stoddard solvent, etc.), or are reformed. Cracked naphthas may also be used but products therefrom require the addition of inhibitors or further treatment to remove olefines and other unsaturates.

Unlike paraffinic hydrocarbons, higher boiling aromatic fractions have higher octane numbers than lower boiling ones. Octane numbers of 90 to 100+ are readily obtainable in materials boiling between 225 and 400° F.

A large plant for the extraction of toluene from petroleum by a modification of the Edeleanu Process is now under construction.

Kerosenes

The improvement of quality which SO_2 extraction produces on kerosenes is well known and requires no comment in this writing.

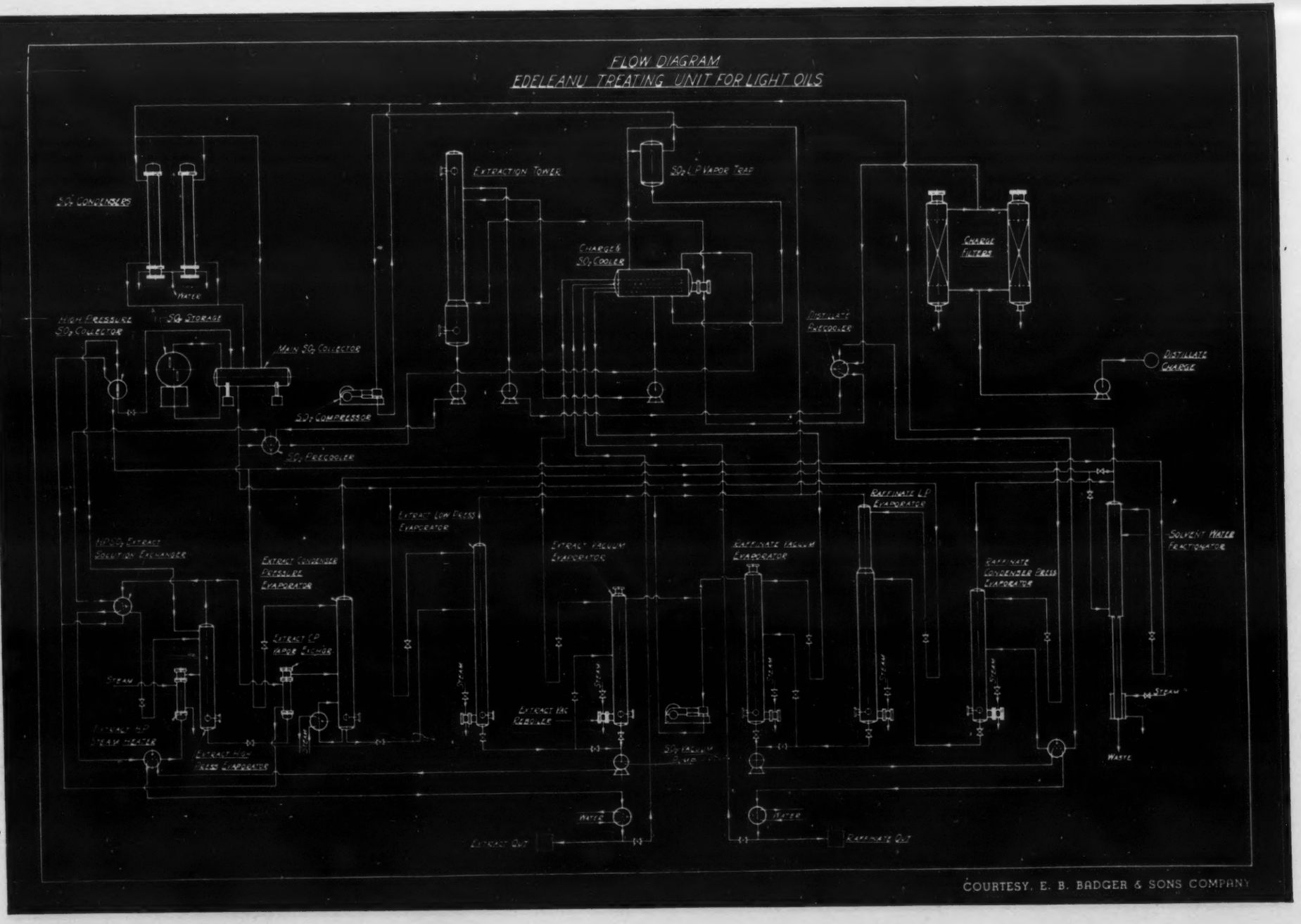
Diesel Oils

The widely increased use of Diesel engines for transportation on land as well as in the air has stirred the interest in the Edeleanu Process for producting better fuels. Higher cetane numbers and diesel indices and lower carbon residues and sulfur contents are obtained in SO_2 raffinates produced both from straight-run and cracked gas-oils, than available in "natural" diesel oils including those from Pennsylvania crude. Diesel indices of SO_2 refined gas-oils range from 74 to 80 for paraffinic and cracked stocks based on extraction with 150 VOL. % SO_2 at +30° F. Unrefined Pennsylvania gas-oil distillates have diesel indices of only 58 to 68.

Lubricating Oils

Finished lubricating oils of zero degree pour point and 90 to 100 viscosity index with corresponding improvement in carbon residue, stability against oxidation and other important characteristics are obtained from mixed base stocks by the Benzol-SO_2 process described above.

This information is presented through the cooperation of E. B. Badger & Sons Company, Boston, Massachusetts, United States agents for Edeleanu, G.m.b.H.



COURTESY, E. B. BADGER & SONS COMPANY

Two-Stage Crude Distillation Unit

FOSTER WHEELER

THE continuous production of a maximum yield of specification products plus operating economy and flexibility are the fundamental requisites of a satisfactory crude processing unit.

A successful combination of the above factors illustrated by a recently completed 30,000-barrel-per-day crude preflash and two-stage distillation unit. This plant was designed to process four different crudes into 11 specification products which could be individually varied to conform to seasonal market requirements.

Special features are incorporated in the unit to permit long runs without trouble due to plugging of exchangers and furnace tubes with salt deposits, to minimize the combined corrosive effects of sulphur, hydrogen sulphide and hydrochloric acid and to caustic treat the charge to the vacuum unit. The unit is designed to recover 225° F. endpoint gasoline, two naphtha fractions, a tractor fuel fraction, two gas oil fractions, four distillate lube fractions and a residue amounting to 10 percent by volume of the charge.

As shown on the accompanying flow chart presented here through the cooperation of Foster Wheeler Corporation, 165 Broadway, New York, N. Y., the unit consists of a three-tower arrangement, recovering the light gasoline overhead from a prefractionating tower where water and hydrogen sulphide are also flashed off the crude. Nonviscous fractions are recovered from a second column operating under substantially atmospheric pressure. In a third column, operating under vacuum, the viscous fractions are removed. Since light naphtha having an endpoint as low as 225° F. is desired, a prefractionating column is preferable to the usual single flash atmospheric tower for the following reasons:

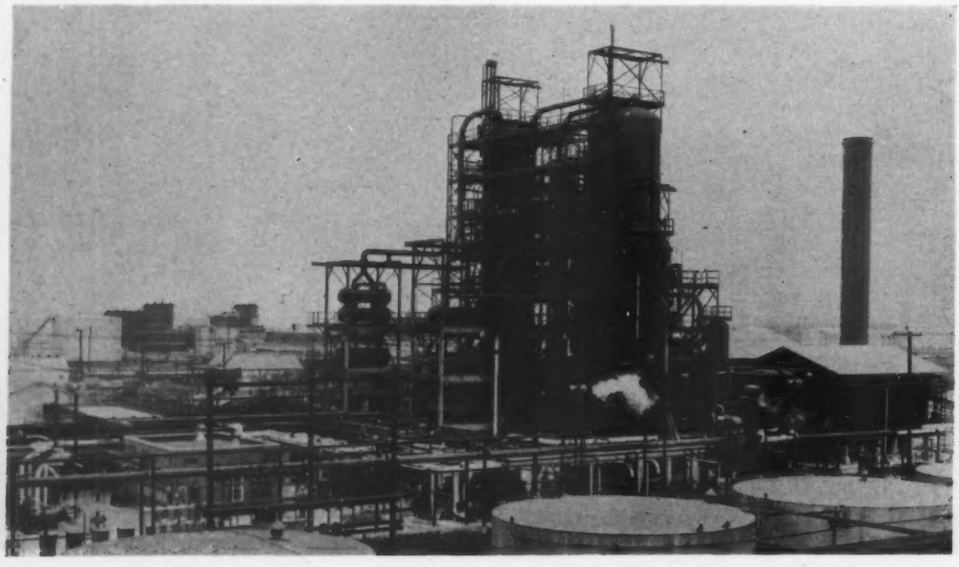
1. When a prefractionating column is used to remove the fractions with lowest boiling points, the top of the atmospheric column may be operated at a relatively high temperature level. Consequently the large amount of reflux heat available at the top of the column permits effective use of heat exchange surface.

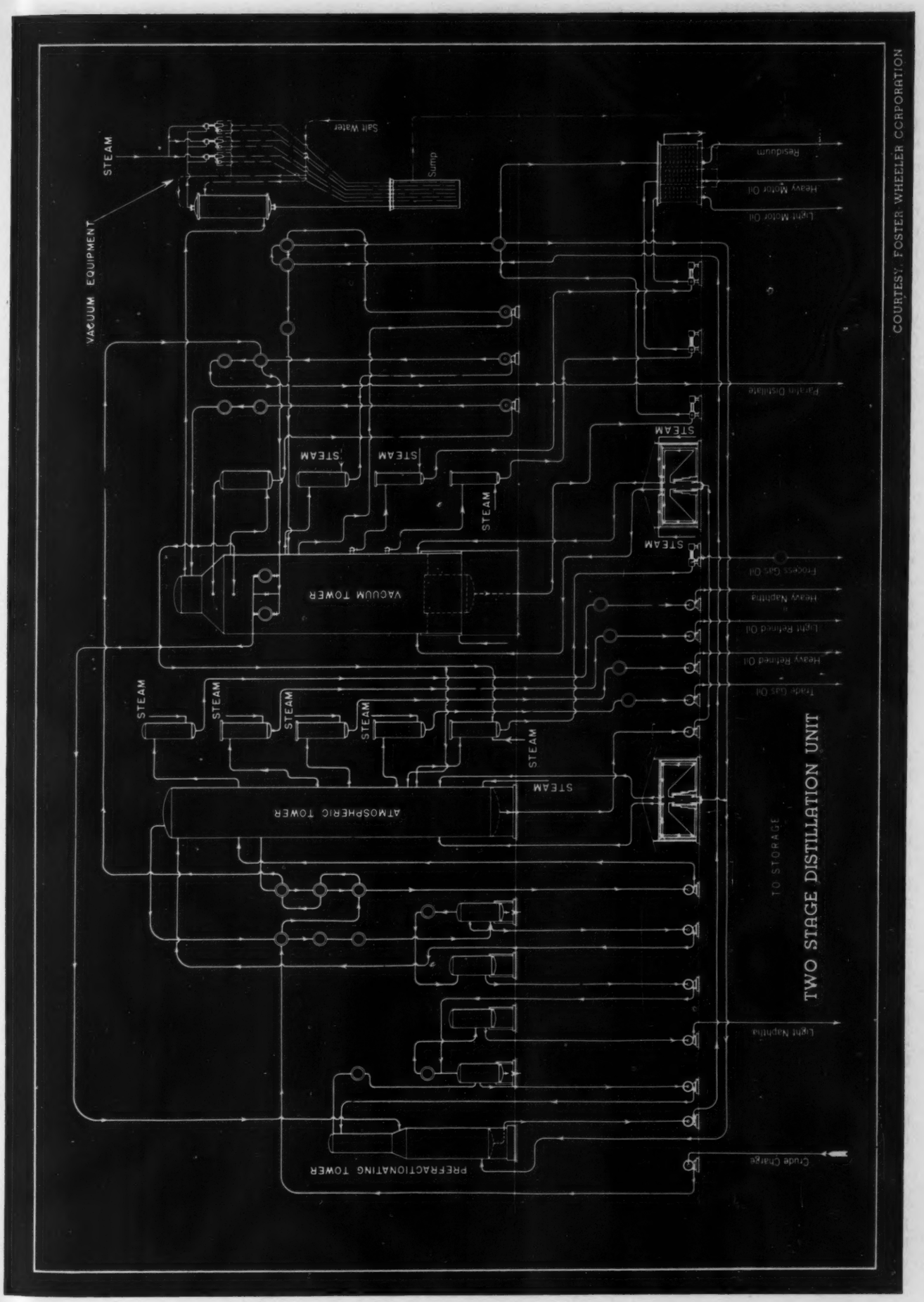
2. Open steam is not used in the operation of the prefractionator but it is used both in the base and in the sidecut stripper of the atmospheric column. Because the top of the atmospheric column is operated at an elevated temperature, no difficulty is experienced with condensation of water on the upper trays. Likewise, the possibility of corrosion at the top of the atmospheric column is entirely eliminated, inasmuch as there is no opportunity for hydrochloric acid vapors—formed by the hydrolysis of the salts at the base of the atmospheric column—to condense in the upper section of the tower.

3. Preflashing effectively dehydrates the crude oil and makes it possible to heat the flashed crude in subsequent stages to any desired temperature without the deposition of salts within the heat exchanger or furnace tubes.

While the unit as now operated permits satisfactory operating cycles which are not limited by deposition of salt in tubular equipment, it is normally recommended that similar units be equipped with salt settlers for the separation of water-salt mixture from the crude oil at an intermediate point in the heat exchanger circuit. A salt settler has the advantage of eliminating the salt from the system before it reacts to generate hydrochloric acid vapors. This prevents any trouble in the condensing equipment arising from hydrochloric acid corrosion and likewise effects considerable economy by reducing the quantity of ammonia required for neutralization of the condensed overhead vapor streams.

Due to the wide variation in yields of the side-cut streams from the atmospheric tower, the heat exchangers are located in the reflux circuit rather than in the product lines to storage in order to maintain uniform crude preheat temperatures under all operation conditions. A circulated reflux system is used in the atmospheric fractionating column below the heavy naphtha draw-off and also in the vacuum column below the wax distillate side-cut, in order to obtain maximum economy in heat exchange.




TWO STAGE DISTILLATION UNIT
COURTESY FOSTER WHEELER CORPORATION
STEAM
VACUUM EQUIPMENT
Salt Water
Sump
Residuum
Heavy Motor Oil
Light Motor Oil
Parafin Distillate
STEAM
STEAM
STEAM
STEAM
STEAM
VACUUM TOWER
Process Gas Oil
Heavy Naphtha
Light Refined Oil
Heavy Refined Oil
Trade Gas Oil
STEAM
STEAM
STEAM
STEAM
STEAM
ATMOSPHERIC TOWER
TO STORAGE
Light Naphtha
Crude Charge
PREFRACTIONATING TOWER

Houdry Catalytic Cracking Process

SINCE the previous Process Number of Refiner and Natural Gasoline Manufacturer, actual operating experience with thirteen units in the United States, together with intensive research, have resulted in steady advances in Houdry Catalytic Cracking. The major improvements are higher gasoline yields and octanes in the catalytic conversion of heavy overheads from reduced crudes, gas oils and the reforming of certain naphtha stocks. Gasoline yields on the order of 65 percent can be realized from high boiling point fractions and up to 75 percent from gas oil charging stocks. Octanes of 79-81, motor method and 90-93 by the research method are being realized. With naphthas from Coastal or certain California crudes, high yields of high octane motor gasoline are being attained.

A large amount of commercial experience has been obtained in the manufacture of aviation gasoline base stocks by Houdry Catalytic Cracking of gas oils and naphthas. Pilot plant processing has covered a wide range of suitable stocks. The aviation base from these stocks requires no treating to meet specifications and the product reaches 91-94 octane (AFD-IC method) with approximately 3 c.c. per gallon of tetraethyl lead. With moderate quantities (35-40 percent) of alkylate or other high octane blending agent and 3 c.c. per gallon of tetraethyl lead, 100 octane finished aviation fuel is obtained.

The above outlined improvements are the result of new types of catalysts rather than radical changes in basic design. The new types of catalyst have made economically possible the recycling of the catalytic gas oil. The main components of a Houdry Catalytic Cracking unit for charging reduced crude once through are shown on the flow sheet on the opposite page. The raw feed is pumped through heat exchange and thence to a pipe heater where the temperature is raised to approximately 850° F. and the charge transferred to the tar separator. The heavy unvaporized portion or pitch is removed from the bottom of the tar separator, passed through a cooler and thence sent to storage for blending off with cracked products for heavy fuel. The vaporized portion passes from the tar separator to one of the catalytic converters, the vapor stream being automatically diverted from converter to converter as required for the regeneration cycle. The catalytically cracked vapors pass through vapor heat exchange to the synthetic crude tower where the gasoline, No. 2 fuel oil and gas oil are fractionated out and passed to storage.

During the regenerating cycle the oil vapor inlets and outlets are automatically closed, a vacuum is pulled upon the converter for removal of oil vapor and then preheated air is admitted from a turbo compressor. The carbon deposit is burned from the catalyst and the excess heat so generated is removed by means of a molten mixture of nitrates and nitrites of sodium and potassium. This excess heat so removed is used for steam generation or preheat of the charge. The gases of combustion from the converter pass to the turbine side of the turbo compressor and have sufficient energy to provide all the power required for air compression and some excess which is used for the generation of electrical power. At the end of the regeneration period a steam jet removes the products of combustion that remain in the converter and after repressuring the catalyst is again ready to receive oil vapor conversion.

In the event this type of once through operation is to be applied to gas oils or naphthas the tar separator may be by-passed (or omitted in the original design) and the plant operated otherwise substantially as for the reduced crude operation. From gas oils and heavier charging stocks, the single pass operation results in gasoline yields of 40-50 percent based upon case charge. For a given quantity of fresh feed stock, a recycling operation as compared with a once through does not change the size or cost of the catalytic equipment.

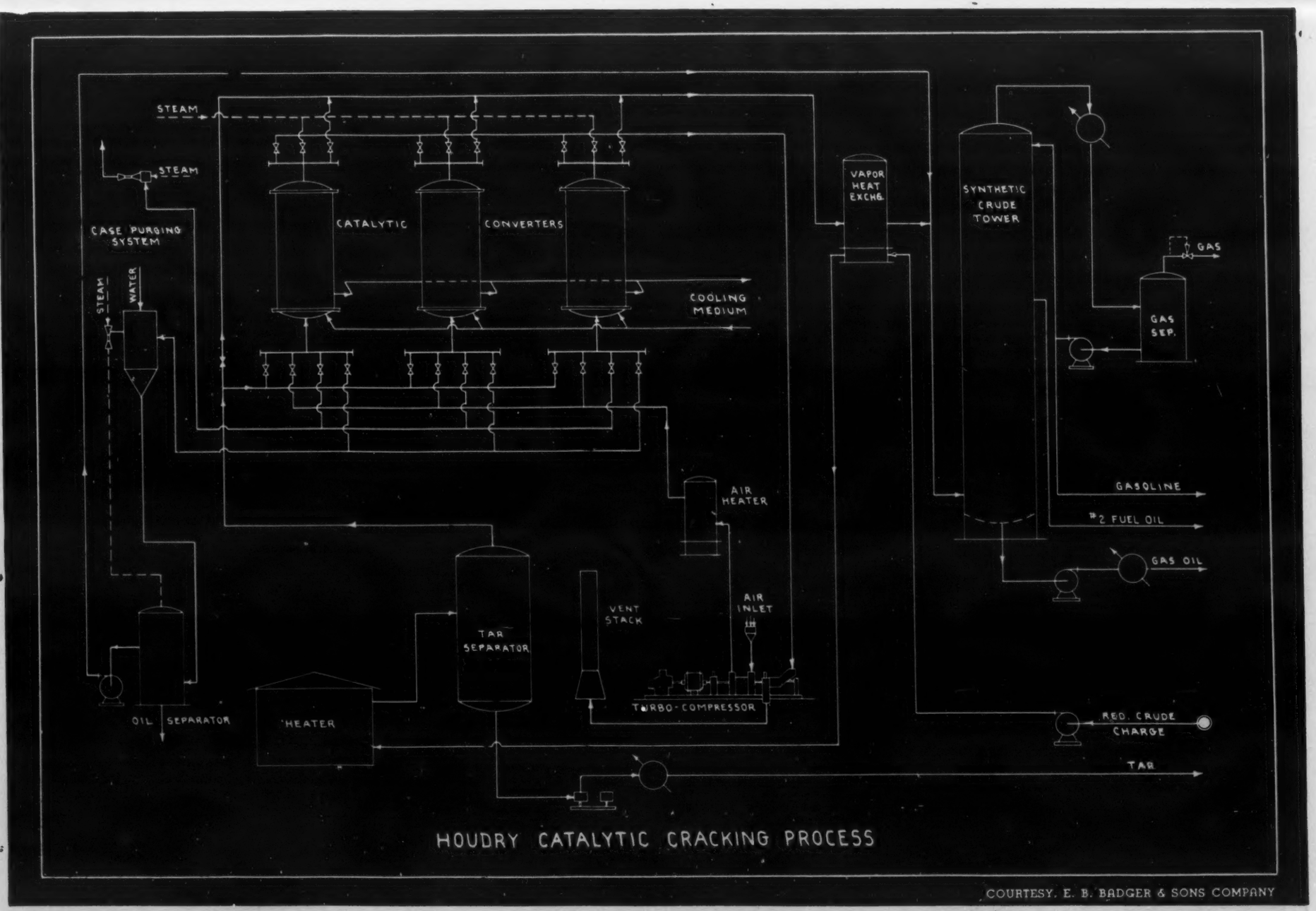
Either the once through or the recycling operations on gas oils and heavier, give overall recoveries of liquid products usually representing 90 percent or more of the virgin case charge. The difference between liquid recovery and gasoline yield represents gas oil which generally has an A.S.T.M. end point not substantially higher than 750° F.

When reforming selected naphthas, motor gasoline yields may be of the order of 80-95 percent. When processing either naphthas or gas oils for aviation manufacture, the heavy naphtha above the aviation boiling range is also of high octane and may therefore be used in motor gasoline blends.

One of the Houdry units placed in operation during the past year is a naphtha reforming unit of 7500 B.P.D. charging capacity. This unit has been used for the manufacture of aviation base stock as well as entire motor gasoline. Another of the recently completed units is designed for a normal once through fresh feed capacity of 20,000 B.P.D. of mixed gas oils.

With the Houdry units now under construction, full advantage of commercial experience and research developments has been taken. The flexibility of Houdry units is well illustrated by one unit that will be capable of processing alternately either heavy gas oil on the recycling basis, heavy naphtha on a recycling basis, or a lighter naphtha once through. In still another unit, the moderate recycle ration will be varied to maintain the seasonal balance of the refinery.

With the completion of the units under design and construction, there will be sixteen operating Houdry Units in the United States with catalytic cracking capacities ranging from 8,000 to 20,000 barrels per day.


STEAM
STEAM
CASE PURGING SYSTEM
STEAM
WATER
CATALYTIC
CONVERTERS
COOLING MEDIUM
VAPOR HEAT EXCHG.
SYNTHETIC CRUDE TOWER
GAS
GAS SEP.
GASOLINE
#2 FUEL OIL
GAS OIL
AIR HEATER
TAR SEPARATOR
VENT STACK
AIR INLET
TURBO-COMPRESSOR
OIL SEPARATOR
HEATER
RED. CRUDE CHARGE
TAR
HOUDRY CATALYTIC CRACKING PROCESS
COURTESY, E. B. BADGER & SONS COMPANY

The Hydroforming Process

THE Hydroforming Process produces high octane gasoline from straight-run and cracked naphthas by catalytic reactions which may be considered as combined dehydrogenation and aromatization. The reactions take place in a hydrogen-rich atmosphere which is maintained by recirculation of product gas. One feature of the process is the almost complete removal of sulphur, even from high sulphur naphthas.

High octane base blending stocks for aviation fuels, as well as aromatics for the production of toluene and high solvency naphthas, may also be produced if desired, preferably from straight-run naphthas.

Units of pilot plant size in the laboratory, a 100 bbls. per day semi-commercial unit and a demonstration unit of over 1000 bbls. per day capacity have been operated over the past few years. The first commercial unit recently completed is at present in operation. This plant is capable of reforming approximately 7500 bbls. per day of 40-45 octane heavy naphtha to an 80 percent yield of 80 A.S.T.M. octane gasoline.

The flow plan of the unit is simple as may be noted by reference to the flow diagram on the opposite page.

The fresh charge, after passing through a heat exchange system, is passed through a heater coil, emerging at elevated temperature and above atmospheric pressure. The heated material is then joined with gas recycled from the gas separator and the mixture flows into a catalytic reactor where the conversion of the fresh charge takes place to produce high octane gasoline, gas and a small amount of heavy polymer.

The effluent from the reactor, after flowing through a system for heat exchange, is discharged into the gas separator. A portion of the separator gas is compressed, passed through a heater coil, and combined with the hot naphtha feed, as described previously. The remainder of the gas is sent to the absorber in the refinery. The liquid products from the gas separator, consisting of reformed gasoline and heavy polymer are charged to a stabilizer. Bottoms from the stabilizer flow to a rerun tower. The overhead from this tower which is product gasoline, is condensed and sent to storage, and from the bottom of the tower is withdrawn a small amount of heavy polymer produced in the operation. The rerun tower is designed to permit, if desired later, fractionation of the gasoline into two cuts, the lighter cut being an aviation fraction.

Eventually the deposition of coke on the catalyst in the reactor reaches a point where it becomes necessary to revivify the catalyst by removing the coke. After a chamber has gone through a reaction period, it is removed from the system, its place being taken by another chamber containing reactivated catalyst. A reactivating gas is passed through the chamber for revivification of the catalyst. Practically all valve changes made in switching the reactors from reaction to regeneration are automatic.

Other units of an essentially similar nature are at present under construction and are expected to start operation in the very near future.

A hydroformer of a somewhat different design is also being built at the present time. This unit is designed to charge a mixture of straight-run and cracked heavy naphtha of high sulphur content and produce a high yield of high-octane, low sulphur motor fuel.

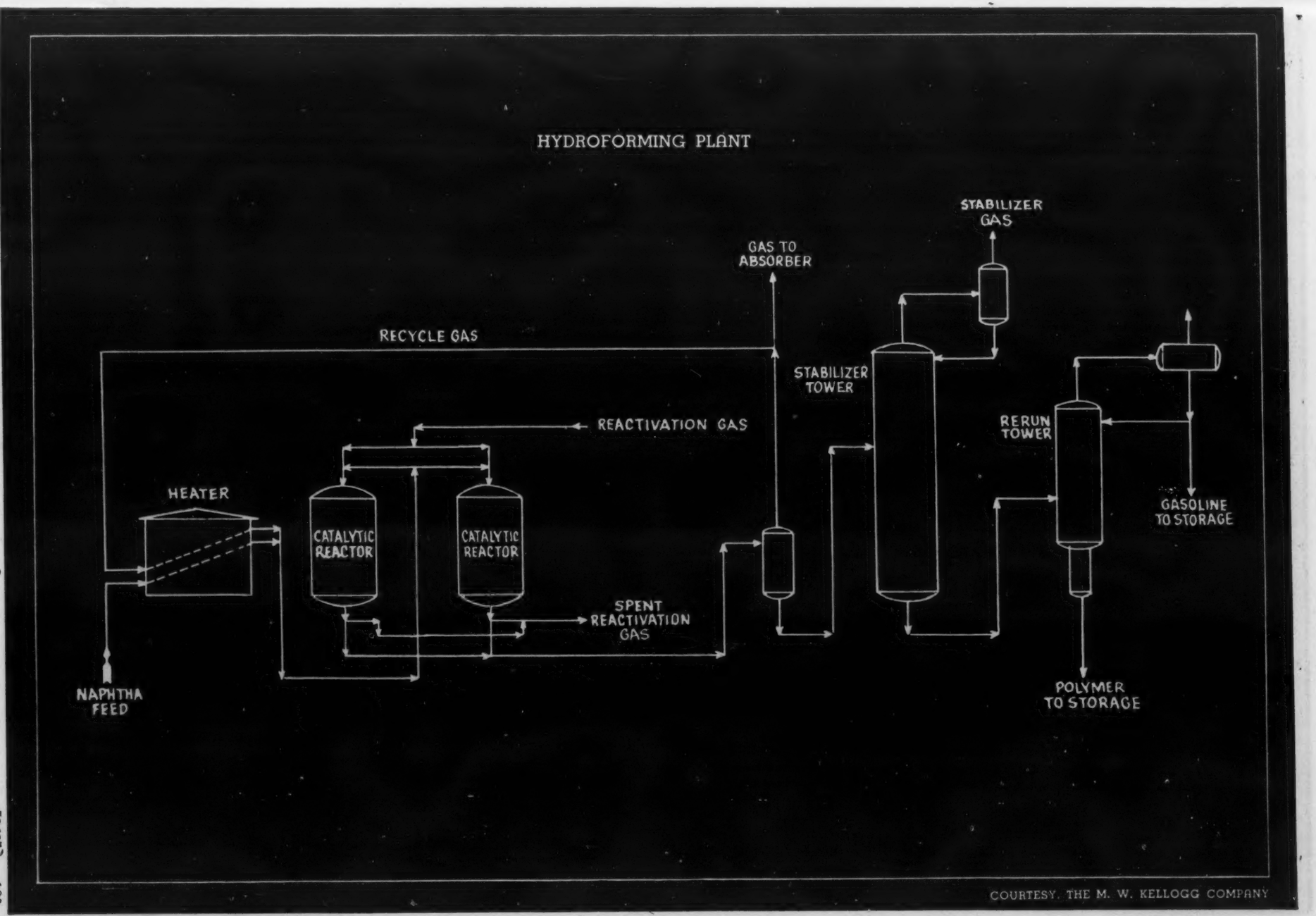
The flow is similar to the flow through the hydroformer previously described, except that special design provisions have been made for handling the high sulphur, straight-run and cracked gasoline mixture, and more than two catalytic chambers are installed.

Although this process is sufficiently flexible to produce gasoline having an A.S.T.M. octane value as high as 90 from most heavy naphthas, the usual designs are being made at the present time for the production of approximately 80 A.S.T.M. octane number gasoline.

The product from the Hydroforming Process on straight-run heavy naphthas usually contains 50 percent of aromatics when going to 80 Motor octane number, with a high percentage of toluene and xylene being present in the aromatics.

Another characteristic of the product is that the higher boiling range product above 400° F. may be included in the gasoline without reducing the octane of the overall product; in some cases an increase has been noted. In many instances the hydroformed gasoline may be included in the finished gasoline with no further treatment whatsoever, although some refiners may wish to add a small amount of inhibitor to retard the almost negligible gum formation in storage.

Licenses for the operation of the process are available through The M. W. Kellogg Company.


HYDROFORMING PLANT
STABILIZER GAS
GAS TO ABSORBER
RECYCLE GAS
STABILIZER TOWER
REACTIVATION GAS
RERUN TOWER
HEATER
CATALYTIC REACTOR
CATALYTIC REACTOR
GASOLINE TO STORAGE
SPENT REACTIVATION GAS
NAPHTHA FEED
POLYMER TO STORAGE
COURTESY, THE M. W. KELLOGG COMPANY

Knowles Coking Process

THE Knowles process of treating residuums has for its object the recovery of liquid products overhead, accompanied by the formation of coke at higher temperatures than is possible with the usual type of chamber apparatus. Most of the essential qualities of coke vary with the temperature to which it has been subjected in the course of processing. These qualities include hardness, volatile content and true density.

Chamber coke is soft and contains up to fifteen per cent of volatiles. Metallurgical coke requires hardness, which is tested by its ability to resist both breakage and abrasion. It also requires a volatile matter content preferably below two per cent, a moisture content of three per cent or less, and a size preferably ranging upward from two inches to six inches, the larger dimension corresponding to the established preference for foundry coke.

Electrode coke requires a volatile content below one-half of one per cent, and a true density of the coke substance, neglecting the pores, of about twice that of water. Such a density combined with so low a volatile content can only be obtained in an apparatus where the temperature can be raised to 2300° F. or higher.

The Knowles process employs a retort adapted to distillation and to subsequent heating of the resultant coke up to the temperatures necessary for metallurgical or electrode coke. This is a steel encased refractory lined furnace fired at either end, and provided with parallel longitudinal combustion flues below a floor, which is made of a brick having a carborundum base. The brick has a heat conductivity practically equal to that of metals and is impervious to oil. The charge is fed into the furnace hot, with formation of coke on the floor, and withdrawal of overhead vapors through a standpipe in the top of the oven. This standpipe connects to a vapor main which leads to a tower and to other apparatus in which the overhead is further processed.

The operation is cyclic and the size of an individual charge is limited by the heat conductivity of the carborundum floor and of the coke. When completely coked, the layer is about eight inches thick, corresponding to about six tons of coke per charge. The oven is closed at either end by a removable door and the coke is removed by pushing, much as in ordinary coke oven practice. The time required for pushing and for preparing to resume charging is less than 30 minutes. Each oven is valved in the connection between off-take and vapor main so that it may be separated from other ovens and from the overhead system.

The Knowles oven is adaptable to any petroleum refining system where it is desired to form coke. It has been successfully applied both to the treatment of cracked residue and to a flashed residue before cracking. In the former case viscosity breaking with attendant recycling may be employed. In the latter case recycling is also usually practiced. The general circumstances of the flow are not affected by the Knowles process.

Exhaustive pilot plant operations indicate the possibility of recovering substantial yields of benzol and toluol from suitable stocks by controlled cracking of the vapors within the oven. A plant is now under construction with this object in view. On the other hand cracking may be held to a minimum with formation of about eight per cent of gas.

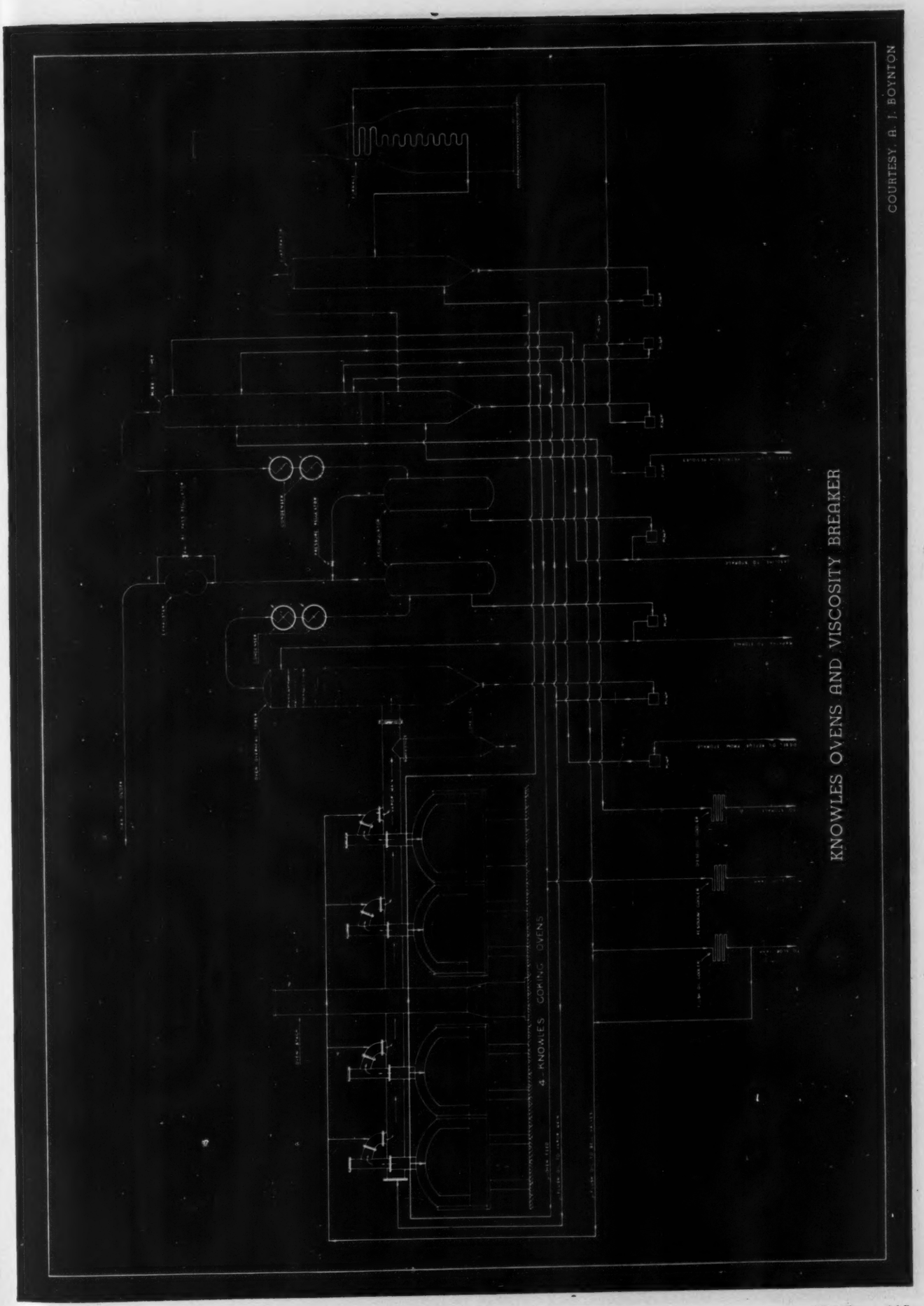
The flow chart on the opposite page illustrates the processing of cracked residue with attendant viscosity breaking and production of a metallurgical grade of coke.

The residuum to be treated is introduced at as high a temperature as possible. Usually on the order of 700° F., into a flashing space at the base of the fractionating tower. From this point, the feed, together with additional oil from the recycle section of the fractionating tower, is passed up through the tube still, where it is heated to a temperature of 890° F. As previously stated, the bottom from the flashing operation is approximately 1½° API gravity, the temperature of the evaporator bottom being about 750° F. These bottoms are then pumped to the Knowles ovens. The overhead passes up in the fractionating tower, from which it is joined by the overhead vapors from the ovens.

The oven cycle is six hours or less, of which 1½ hours is occupied in feeding and the balance in coking and devolatilizing the charge.

This flow is not fixed and may be modified so as to accommodate itself to a variety of refinery operations. Essentially, the process consists in heating the residue, flashing it and recovering the overhead from the flashing operation as clean oils lighter than the feed and converting the bottom into dense firm coke.

Under usual conditions of operation, cracking processes are terminated at the point which gives a residuum sufficiently light and fluid to be capable of easy handling at ordinary temperatures. In the absence of an economical and convenient coking process, the only end product which accompanies further cracking is asphalt. The manufacture of coke by the Knowles process permits the cracking to be carried down to one gravity residuum, which goes directly to the ovens. This description was furnished by A. J. Boynton, 310 South Michigan Avenue, Chicago.



KNOWLES OVENS AND VISCOSITY BREAKER

COURTESY, A. J. BOYNTON

Lubricating Oil Processing System

THE LUMMUS COMPANY

IN CONNECTION with the production of high quality lubricating oils using solvent processes for refining and dewaxing, The Lummus Company, 420 Lexington Avenue, New York, has made a number of developments in the direction of correlating the various operations involved with the object of tying in the various steps so that the system as a whole will have the greatest flexibility, performance and economy of operation.

The complete processing system is shown by the accompanying diagram. Topped crude is taken as the starting material and is charged to a combination Vacuum-Carrier Distillation Unit. The vacuum distillation tower provides for the removal of the light and intermediate lube oil distillates. The residue from vacuum distillation is charged to a Carrier distillation unit which further reduces the vacuum tower residue to minimum percentage asphalt bottoms. By this system all of the available lube oils present in the topped crude can be recovered as distillate stocks. Intermediate storage is provided for the various grades so that they can be charged to the solvent refining unit separately.

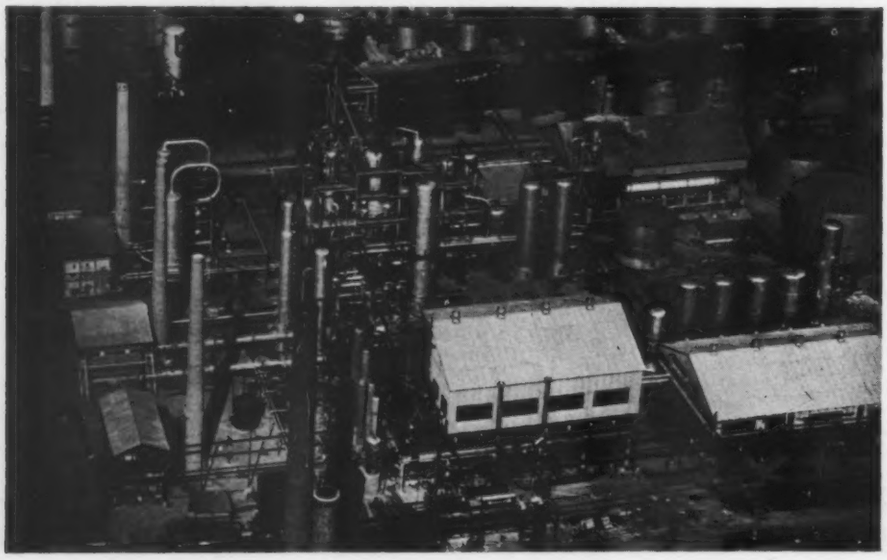
A satisfactory solvent for use in the solvent refining step is furfural (the process employing this solvent is patented, the patents being owned and licensed by The Texaco Development Corporation). In application on a wide variety of raw lube oil stocks treated in existing furfural units the flexibility of this solvent process has been completely demonstrated. Both the first cost of this type of solvent refining unit and the operating cost are low taking into consideration the results obtained. The raffinates resulting from the refining of the various grades of raw lube distillates are again sent to intermediate storage.

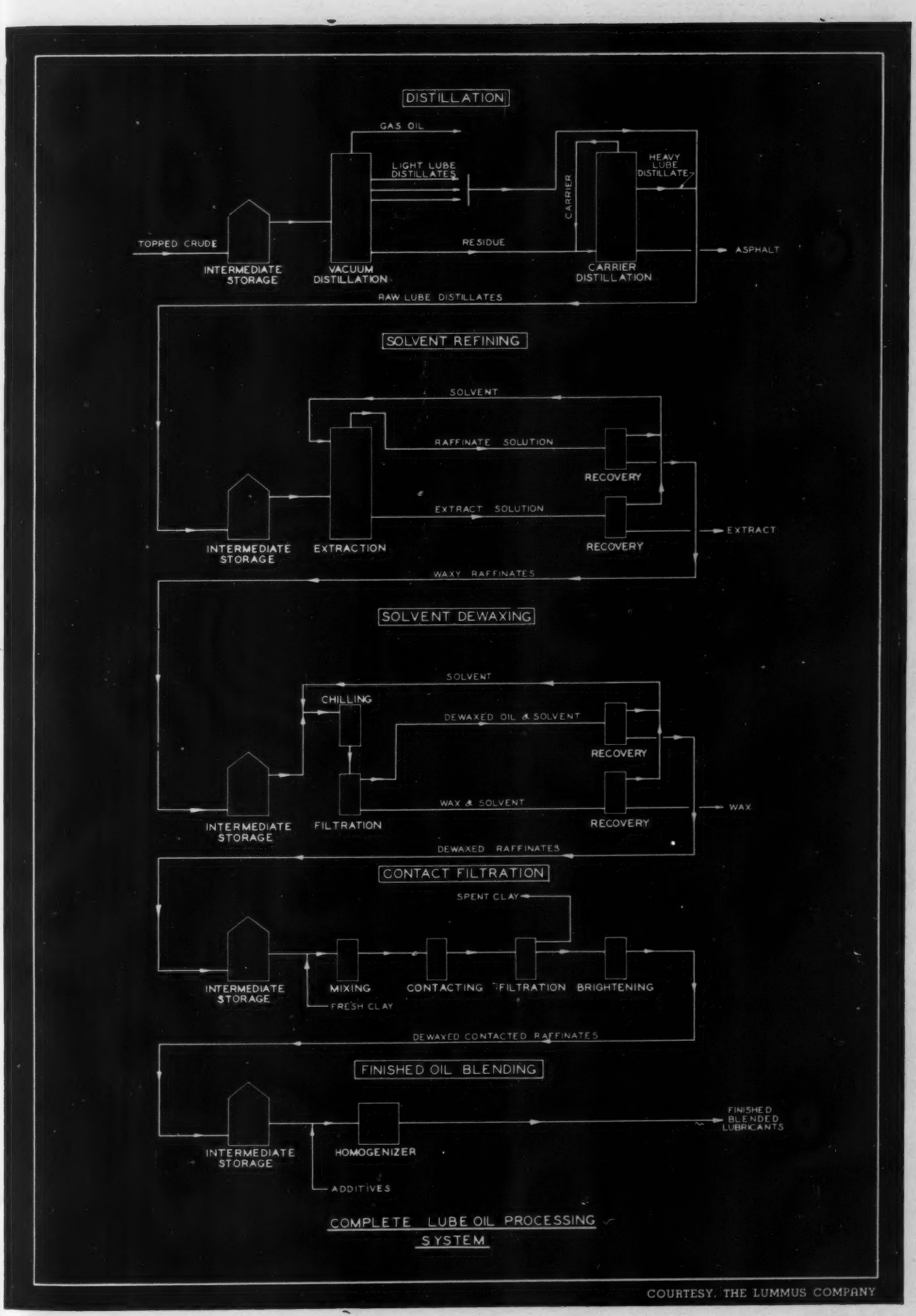
The raffinates from intermediate storage are then charged to the solvent dewaxing system. A widely used system and one with great flexibility employs a mixture of acetone or methyl ethyl ketone and benzol (this system is covered by patents owned by and licensed by The Texaco Development Corporation). The essential steps in this process are (1) mixing of oil and solvent, (2) chilling of the mixture to low temperatures, (3) removal of precipitated wax by filtering and (4) recovery of solvent from wax and from wax free oil by distillation. The wax recovered from such a process is of excellent quality and relatively free from oil. The oil recovered has a low pourpoint in order to meet modern requirements for high quality lubricating oils. The wax free oils of the different grades are again sent to intermediate storage.

The final step in finishing high quality lubricating oils is satisfactorily accomplished by the use of contact filtration. In this step the oil obtains the necessary treatment for giving it the required color, neutralization number, etc. The essential steps in contact filtration include (1) the mixing of dewaxed oil with fine acid treated clay, (2) heating of this mixture to the proper temperature for obtaining maximum efficiency of clay, (3) agitating the heated mixture long enough for the reaction to take place, (4) cooling to proper filtering temperature and (5) filtering the oil from the spent clay.

In view of increasingly severe requirements for lubricating oil quality the use of additives has become generally accepted. Such materials give more desirable characteristics from the standpoint of detergency, oxidation stability and pour point. The addition of such materials is easily carried out in connection with the final blending operation. The Lummus Cornell homogenizer has found wide use because of its reliability, accuracy and economy as evidenced by the large number of installations of this machine in lubricating oil blending service.

The system described above has shown itself to be very satisfactory as evidenced by results from a complete refinery recently put into operation. This refinery is operating on poor quality crude but the finished products obtained indicate that the system has all of the required flexibility as regards production of different grades of lubricating oils in both the average quality and high quality market ranges.





COMPLETE LUBE OIL PROCESSING SYSTEM

COURTESY, THE LUMMUS COMPANY

Lummus Superfractionation Process

THE commercial production of pure petroleum hydrocarbons and concentrates has increased rapidly in the last few years. Propane, normal and isobutane, butane-butylenes, normal and isopentanes have been produced by fractionation in sizeable quantities. More recently, the demand has increased for the isolation of some of the next higher boiling components and fractions of high purity. As a result, The Lummus Company has recently designed and is now erecting a Superfractionation unit for a large oil refining company. The unit employs three towers and produces four products, namely: iso-hexane, normal hexane, iso-heptane and normal heptane and heavier. The towers usually operate in series and remove individual progressively higher boiling point components or fractions.

The iso components generally have boiling points lower than the normal ones. Since many complex chemical structure compounds also occur in petroleum, those that have boiling points adjacent to an iso compound will be found in the iso fraction. Similarly, those compounds boiling near the normal compound will be found in the normal fraction. Any intermediate boiling compound will be distributed between the iso and the normal fraction. However, this compound can be concentrated in either iso or normal fraction by changing the cut point or yield of both fractions to include the intermediate compound in either fraction.

As the front end or light fractions are successively removed the boiling point of the residue or bottoms is progressively raised. If the entire distillation is attempted at atmospheric pressure, the reboiler temperature becomes excessive. The pressure for this operation is reduced by the application of vacuum to allow vaporization of the bottoms for fractionation. Thus it is possible to reboil all bottoms at usual refinery steam pressures. Likewise, the condensation temperature of the overhead products is high enough for normal cooling water temperature.

The distillation characteristics and yields of the products can be varied over wide limits to meet the most exacting requirements. The unusually large number of fractionating or bubble-cap decks together with high reflux ratios enables the refiner to produce products of high purity with high yields.

The unit has operating flexibility such that the towers may be operated in any order and sequence. For example, any overhead product can be charged to either one of the remaining two towers. To utilize all equipment to the best advantage and operate near its maximum capacity, the three towers and associated apparatus may be of different size. Thus, any product of high purity and yield may be removed in the largest tower, another product of lowest purity and yield may be removed in the smallest tower. The best arrangement of towers is possible only after a careful study of such factors as yield, purity, location of fractions in charge and boiling points of distillates and residues.

The location of the optimum feed plate is another factor that must be given careful attention for high purity products. The temperature of the feed, theoretical minimum reflux and plates are also considered in the design and operation of such units.

In some cases, the purity of a product is too high to be obtained in a single tower of reasonable size. However, it may be obtained concentrating in two steps or two towers operating in series.

Where the yield of one product is unusually high, it may be an advantage to operate two of the three towers in parallel. Many other arrangements are possible, hence the flexibility of the unit is easily demonstrated and permits the refiner to handle stocks of widely varying characteristics.

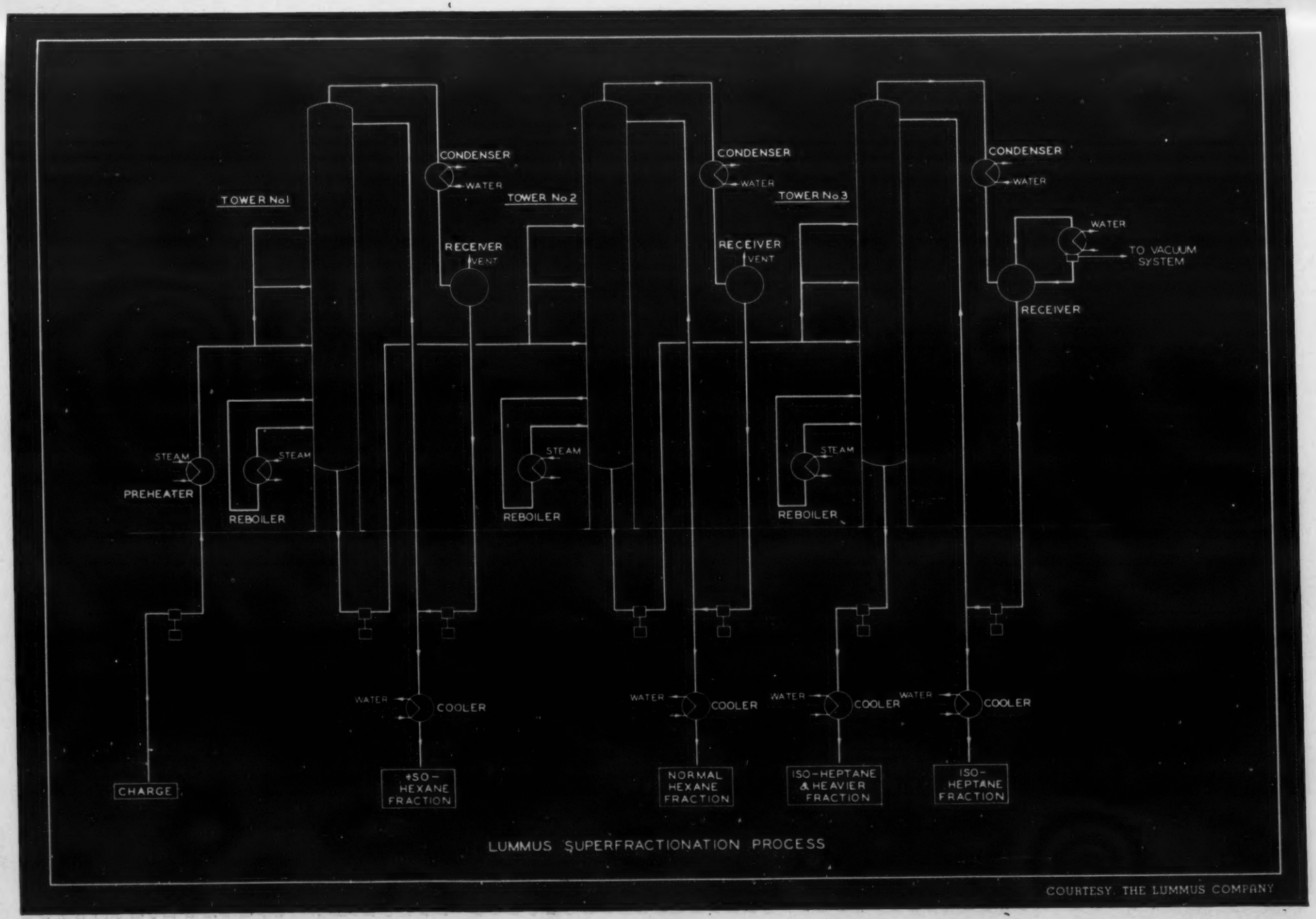
The operation and control of such a plant presents problems of instrumentation. The reboiler temperature, tower top temperature and tower pressure must be maintained within close limits when making products of high purity or narrow boiling range. The pressure control system employs several schemes selected by the operator to fit the conditions.

The flow of reflux and products are measured at all times and any change from the given ratio due to changes in feed composition, feed temperature or reboiling rate is instantly evident to the operator who can make the necessary changes to suit the new conditions.

The vacuum unit is designed for alternate operation under atmospheric or pressure. This requires special attention to the bubble cap deck design to allow a wide range of service.

The tower operations are continuous and once the conditions of flow, temperature and pressure have been established, the products will be those required. It would also be possible to accomplish the same result in a single tower by rerunning either the overhead or bottoms in succession if there is sufficient storage space for intermediate charge stocks. The disadvantages of such a scheme are the time lost in putting the tower on stream and the amount of slop stock made. It is also possible to operate two towers simultaneously if three products are required. Theoretically, any number of towers may be operated in conjunction but practically any more than three would be difficult to control because of dependence of any tower upon operation of all towers ahead in the series.

All the fractionating and heat transfer equipment is of conventional design. The accompanying flow diagram shows a typical arrangement for the fractionation of narrow boiling point products.



LUMMUS SUPERFRACTIONATION PROCESS

COURTESY THE LUMMUS COMPANY

Phenol Extraction Process

PHENOL extraction is being used on a continuously increasing scale for the selective solvent treating of lubricating oils. Large installations have recently been put into commercial operation and there is a total of eleven phenol extraction plants in service with a combined daily charging capacity of about 30,000 barrels.

Accent on viscosity-index improvement in the refining of motor oils has lessened slightly, while the ever growing severity of automotive engine requirements has emphasized the importance of phenol extraction in improving the resistance of refined oil to sludging, carbon formation and lacquer deposition. In addition to greater stability, phenol treated oils show marked improvement in viscosity index, color and carbon residue for a given amount of extract removal.

Phenol is an efficient solvent for the removal of the aromatic, unsaturated and naphthenic constituents of raw lube stocks. Phenol may be used in treating all grades of stocks for moderate or extended improvement as desired, starting with material of low or high viscosity index and taking large or small quantities of extract to effect wide or narrow range changes in paraffinicity. The extent of the treating may be controlled by the quantity of solvent used, while maximum selectivity for the grade of raw charge and for the quality of the raffinate is obtained by controlling the treating temperature through adjustment of the temperature gradient between the most paraffinic and the most naphthenic zones of the treating system and by water injection. The variations in temperature regulate the solubility of the oil components in the phenol. Water, introduced near the extract end of the treater, modifies the solvency of the phenol and releases an intermediate grade of cycle oil from the extract phase which is re-treated in the raffinate phase. The poor quality material in the cycle oil is redissolved in the extract while the more paraffinic material remains with the undissolved raffinate oil.

It is this flexibility in the choice of treating conditions as well as in the choice of solvent quantity which distinguishes the phenol extraction process and gives high treated oil yields regardless of feed or raffinate quality and degree of treatment. Lower phenol solvent ratios are used for a given raffinate yield and quality than for other single solvents, and both waxy and dewaxed stocks may be treated by the process.

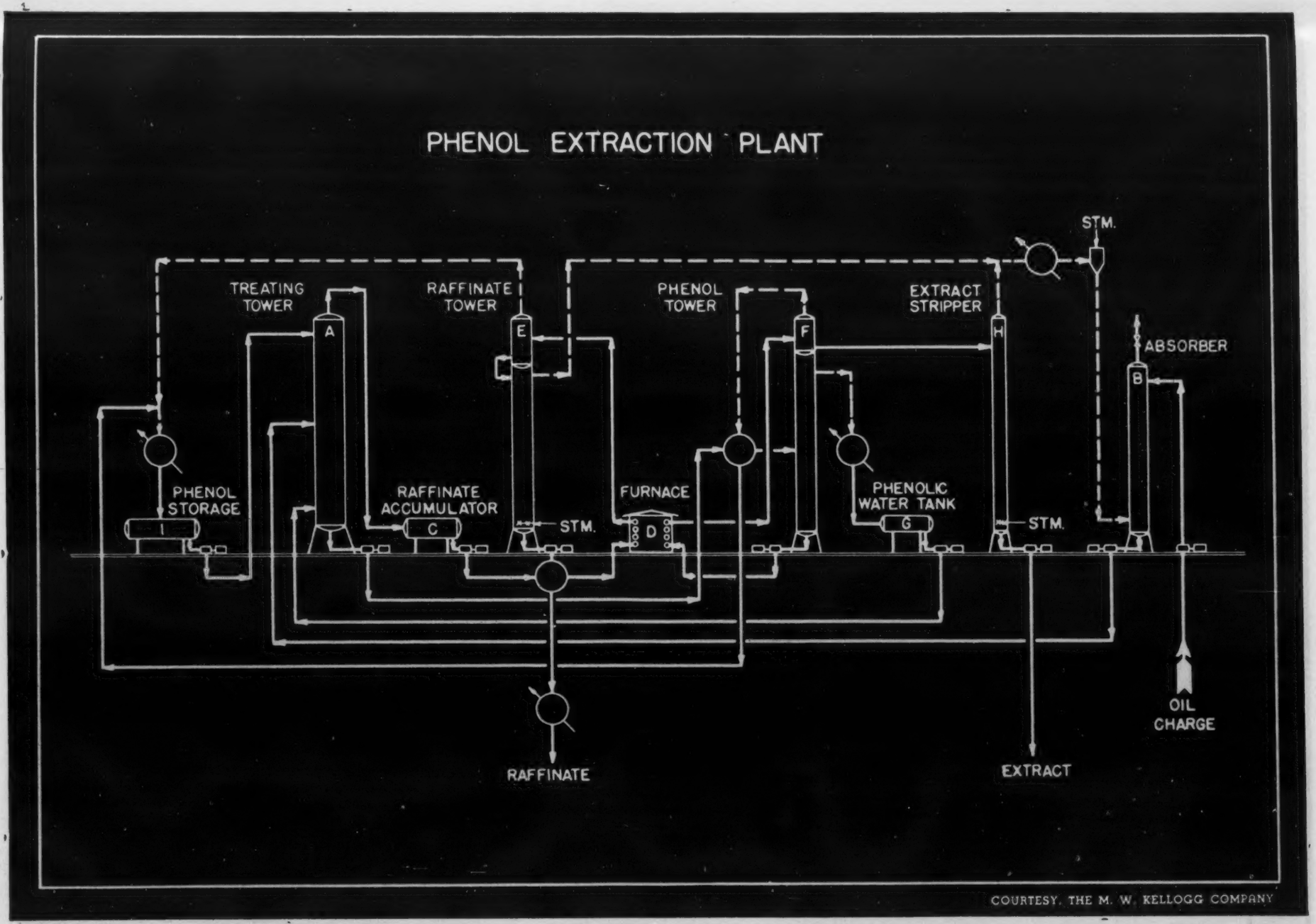
All recent phenol extraction plants have been constructed with countercurrent treating towers in which the phenol solvent flows down by gravity difference through the raffinate oil, collects extract material and settles below the raw feed point which is in the mid-section of the tower. The desired quantity of a water modifier is injected into the tower at a point below the oil feed. The extract phase settles continuously to the bottom of the treating tower, from which it is withdrawn to phenol separation stills where the solvent is recovered by evaporation. The last traces of solvent in the raffinate and extract are removed by steam stripping. Phenol is a stable solvent and does not suffer deterioration with continued use. It may be stripped from oil products at moderate temperature.

A simplified flow diagram outlining the complete treating and solvent recovery systems is shown on the opposite page. Raw stock and dry phenol are fed into treating tower "A." A portion of the feed stock flows through the phenol absorber "B," where it removes phenol from phenolic water constant boiling mixture, before entering the treating tower. Raffinate phase is withdrawn from the top of the treating tower to accumulator "C," from which it is fed through a heat exchanger and through a coil in furnace "D," and is flashed into raffinate tower "E" at substantially atmospheric pressure. Phenol vapor recovered in this section flows to the phenol condenser and enters the phenol storage tank. The raffinate oil is stripped free of solvent in the lower part of this tower with steam and is withdrawn from the bottom to storage. Steam and solvent vapors flow from the top of the stripping section to a surface condenser and steam jet, the purpose of which is to maintain a reasonable vacuum for the stripping operation. The jet discharges uncondensed stripping vapors to the absorber "B" for recovery of phenol as described above. The extract phase is withdrawn from the bottom of the treating tower and is fed through heat exchangers in which heat is recovered from hot phenol, and enters the lower section of phenol tower "F," in which all water is removed as constant boiling phenolic water vapor. The phenolic water vapor leaving the top of this section is condensed and enters accumulator "G," from which is drawn reflux for the drying section as well as the water required for modification of solvent at the bottom of the treating tower. Extract solution is pumped from the bottom of the drying section of tower "F" through a coil in furnace "D," and returns to the evaporating section of tower "F," in which the solvent phenol is recovered as vapor. Heat is given up by the solvent vapor to the drying operation, after which the solvent is further cooled and enters the phenol storage tank "I." Extract oil containing a small amount of dissolved phenol flows from the bottow of the evaporating section of tower "F" to the extract stripper "H," where the last traces of solvent are removed by a steam stripping operation similar to that used for recovery of phenol from raffinate. Stripped extract is withdrawn from the bottom of this tower to storage.

Treating results obtainable with phenol extraction may be gauged from the table below summarizing yields, treating conditions and product quality for several different stocks.

The M. W. Kellogg Company has been appointed licensing agent for the process for the United States and foreign countries. Licenses granted are under the patents and patent rights of the Standard Oil Company (New Jersey), Union Oil Company of California, Standard Oil Company (Indiana), and The M. W. Kellogg Company.

	Pennsylvania Residuum	Pennsylvania Neutral	Mid-Cont. Neutral	Coastal Dist.
Solvent Quantity, Vol. Percent.	87	121	160	100
Treating Temperature, °F.....	240	190	151	127
Raffinate Yield, Vol. Percent..	93.9	88.2	75.1	79.3
Inspections, Untreated Oil	**Propane Dewaxed Deresined**	**Dewaxed**	**Dewaxed**	
Degree A.P.I.....	26.0	29.6	25.4	20.4
Viscosity, SSU @ 210 °F.....	117.2	45.1	47.3	72.8
Viscosity, SSU @ 100 °F.....	1729	182.7	247	1171
Carbon Residue, Percent.....	1.13	0.08	.....	.....
Color, T.R.....	1½	2½	.....	.....
Solid Point, °F.....	—4	—8	.....	.....
Flash, O.C., °F.....	530	420	.....	425
Fire, O.C., °F.....	610	.....	.....	.....
V.I.....	91.9	94.3	70	20
V.G.C.....	0.816	0.825	0.850	.....
Raffinate Oil	**Before Percolation**	**Before Percolation**	**Percolated**	
Degree A.P.I.....	27.2	32.1	31.4	24.8
Viscosity, SSU @ 210 °F.....	113.5	44.4	44.9	65.3
Viscosity, SSU @ 100 °F.....	1545	160.8	176	698
Color, T.R.....	2	8¾	17¾	.....
Solid Point, °F.....	—4	—6	4	.....
Carbon Residue, Percent.....	0.80	0.03	0.005	.....
V.I.....	96.6	107.7	99	62
V.G.C.....	0.808	0.810	0.814	.....


PHENOL EXTRACTION PLANT
STM.
TREATING TOWER
A
RAFFINATE TOWER
E
PHENOL TOWER
F
EXTRACT STRIPPER
H
ABSORBER
B
PHENOL STORAGE
I
RAFFINATE ACCUMULATOR
C
STM.
FURNACE
D
PHENOLIC WATER TANK
G
STM.
OIL CHARGE
RAFFINATE
EXTRACT
COURTESY, THE M. W. KELLOGG COMPANY

Polyco Catalytic Polymerization

IN THE average refinery, cracking and reforming operations are now employed so extensively that there is produced an abundance of light gaseous olefins in excess of those which may be included in gasoline, and unless subsequent utilization of these valuable products occurs they can only be rated as fuel. The Polyco catalytic polymerization process, developed by The Polymerization Process Corporation, is a specific remedy for this undesirable condition.

The research and development work which serves as a basis for the Polyco process was guided by certain definite objectives. It was recognized that the primary purpose of catalytic polymerization was to recover the gaseous olefins by converting them to gasoline. But it was also realized that it would be desirable to produce a polymer of low vapor pressure, so that a large portion of the saturated butanes could be included in the gasoline without exceeding vapor pressure specifications. The economic advantage of such a process is obvious, since it allows olefins and excess butanes formerly rated at fuel value to be sold at gasoline prices.

With regard to quality, the polymer produced by the Polyco catalytic polymerization process is a premium product. The entire polymer may be blended with refinery gasoline without having any adverse effect upon boiling range specifications, since this material itself is gasoline.

Typical inspections of catalytic polymer gasoline are tabulated below:

Gravity	61.5°
A.S.T.M. Distillation	
I. B. P.	116°F.
10 percent	196°F.
50 percent	246°F.
90 percent	352°F.
EP	400°F.
R. V. P.	4.0
CFR-M	82-84
CFR-39R	98-100
Octane Blending Value	110-130

The vapor pressure of butane-free catalytic polymer is extremely low, and therefore the polymer possesses considerable capacity for the inclusion of butanes. The combined effects of the high octane number blending value of catalytic polymer and its ability to increase the inclusion of butane in gasoline result in an appreciable reduction in the amount of lead tetraethyl needed to raise the octane number of the final blended refinery gasoline to a given level. The additional butanes in the gasoline may be credited with a volumetric octane number blending of 90 or above.

The accompanying flowsheet illustrates the simplicity of a typical Polyco catalytic polymerization unit. Liquid feed is first washed with caustic in order to remove certain impurities which tend to impair the efficiency of the catalyst. The purified feed is pumped through a preheater, which in this case is an exchanger recovering waste heat from an adjacent hot gas oil stream. the catalyst bed is divided into two sections in order that either one of the two chambers may be removed from the circuit whenever the catalyst contained therein becomes exhausted. The remaining equipment consists of a transfer line cooler and a stabilizer which separates the polymer from the excess light hydrocarbons.

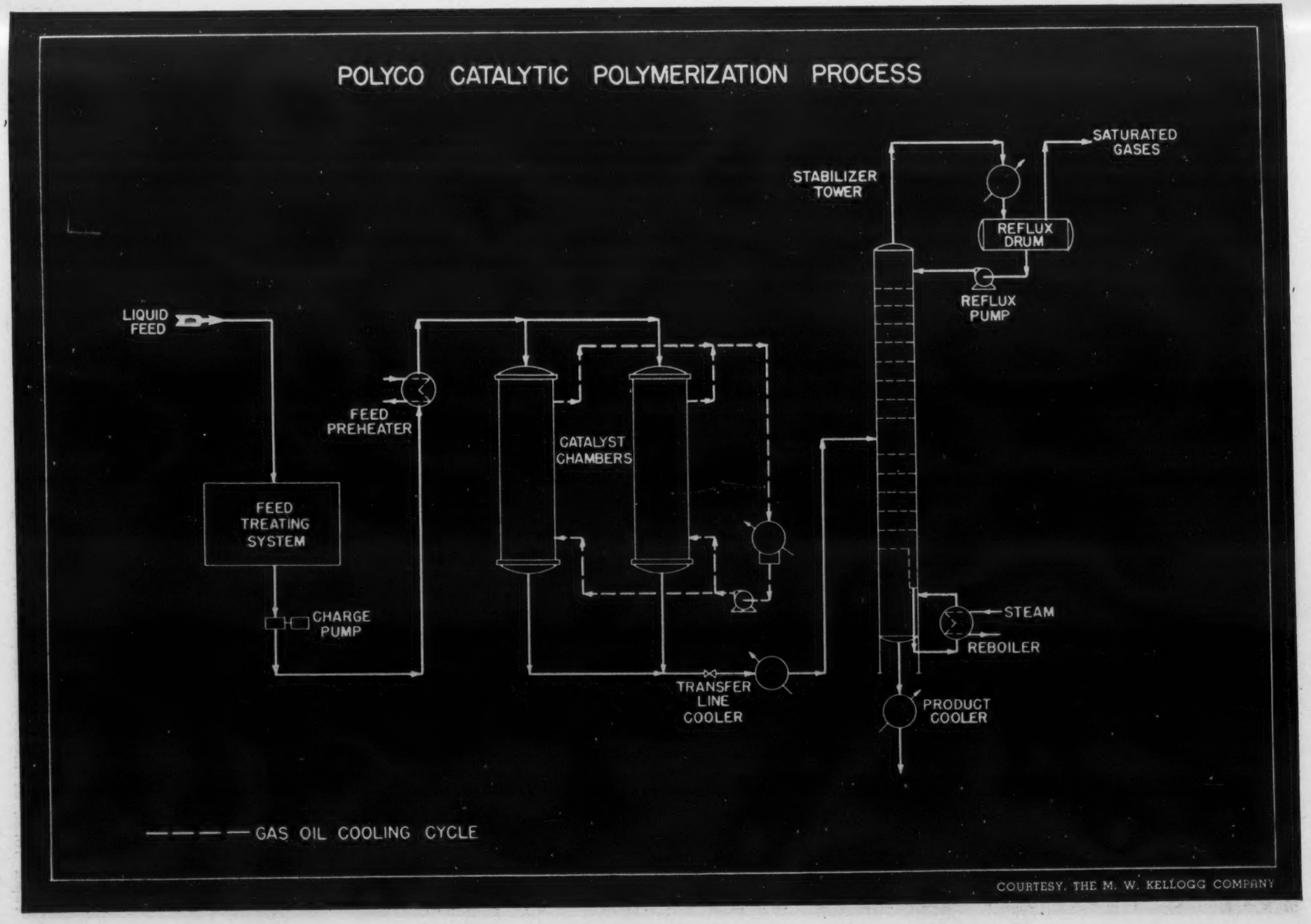
The polymerization reaction is an exothermic one, and in order to control it and to prevent excess temperature rise, it is necessary to provide some means for removing heat. An efficient and inexpensive method of controlling the reaction temperature is to circulate a gas oil stream through the shell side of the converter as shown on the adjoining flowsheet.

Long catalyst life is of paramount importance, since the cost of the catalyst and the number of gallons of polymer produced per unit of catalyst have a direct bearing upon the economic feasibility of catalytic polymerization. By a proper selection of materials and method of preparation, there have been developed catalysts which are sufficiently cheap, rugged and long-lived as to eliminate the necessity for regeneration. The catalysts are merely charged to the converters, utilized until their activity has fallen to an uneconomical point, and then rejected. This makes it unnecessary to provide expensive regenerating equipment and also removes the sometimes hazardous operation of regeneration.

Polymer production is ultimately limited by the quantity of unsaturates, principally propylene and butylenes, present in the feed stock. The maximum polymer production may be obtained by operating the refinery cracked gasoline stabilizer so as to take overhead the C_4 and lighter fractions of the cracked gases. The unsaturated constituents are then polymerized to a low vapor pressure product and with the saturated butanes blended back to the desired specification. In those cases where the cracked gasoline has been stabilized to a low Reid vapor pressure it is advantageous to operate the polymerization unit stabilizer so as to include a high percentage of butanes in the bottoms. This high vapor pressure polymer is then blended back to the desired gasoline specification. For those refineries where the quantity of gasoline marketed is substantially fixed the Polyco process will reduce the crude run by 5-6 percent for the same gasoline production.

The simplicity and flexibility of operation, the ability to produce a high quality product from a charge usually valued as fuel, coupled with the relatively low capital and operating costs, have resulted in a process of economic importance to the refiner, exemplified by fourteen plants at present either operating or under construction in the United States.

The M. W. Kellogg Company, 225 Broadway, New York, N. Y., has been appointed licensing agent for The Polymerization Process Corporation for the United States and foreign countries. Licenses are granted under the patents and patent rights of the Phillips Petroleum Company, Standard Oil Company (Indiana), Standard Oil Company (New Jersey), The Texas Company and The M. W. Kellogg Company.


POLYCO CATALYTIC POLYMERIZATION PROCESS
SATURATED GASES
STABILIZER TOWER
REFLUX DRUM
REFLUX PUMP
LIQUID FEED
FEED PREHEATER
CATALYST CHAMBERS
FEED TREATING SYSTEM
CHARGE PUMP
STEAM
REBOILER
TRANSFER LINE COOLER
PRODUCT COOLER
GAS OIL COOLING CYCLE
COURTESY, THE M. W. KELLOGG COMPANY

Shell Butane Isomerization Process

THE sulphuric acid alkylation process has become firmly established as the most economic method of producing 100 octane aviation gasoline. In this process olefinic fractions, usually butylenes, combine with isobutane in the presence of strong sulphuric acid as a catalyst.

The required olefinic material can be made in cracking or reforming equipment, but usually the isobutane accompanying the olefins is of insufficient quantity to carry out the required alkylation step.

Previously, it has been necessary for a refiner using alkylation to supplement this deficiency of isobutane by extracting a supply of it from natural gas.

In certain localities the procuring of natural isobutane in the required quantities has been either impossible or uneconomic. Through isomerization, however, refiners now have an alternative means of supplying this material.

Briefly, the process is one in which normal butane is converted, under the influence of a catalyst, to isobutane. In any naturally occurring mixture of butanes, or synthetically prepared cut of butylenes and butanes, the proportion of normal butane is greater than that of isobutane. Previously, the normal butane has been a waste product so far as alkylation is concerned; now it can be converted almost completely into isobutane and thence into alkylate, finally appearing in 100 octane aviation gasoline.

A typical analysis of a B-B cut from reforming operations, (i.e., the fraction containing butanes and butylenes) is as follows:

Isobutylene	20.0 percent by weight
Normal butylenes	27.0 percent by weight
Isobutane	18.5 percent by weight
Normal butane	34.5 percent by weight
	100.0

Such a mixture is not suitable as the sole charge stock for alkylation operations as it is deficient in isobutane. However, if normal butane, which is usually discarded from the operation, is taken as charge stock for an isomerization unit, the requisite quantity of isobutane will be formed for charging to an alkylation unit. Some of the normal butane charged to the isomerization unit is unconverted and accompanies the isobutane. The unconverted normal butane is segregated in the fractionation section of the alkylation plant and is once more charged to the isomerization unit, thus the normal butane is recycled through isomerization and alkylation plants until conversion is completed, eliminating the necessity for obtaining naturally occurring isobutane.

The process consists of passing normal butane in vapor form, at moderate temperature, through a granular bed of catalyst, a constituent of which is aluminum chloride. Dry hydrogen chloride gas is incorporated with the butane vapors; this serves to activate the catalyst.

The discharge from a single pass through the catalyst contains a large proportion of isobutane. This flows through a refrigerated condenser which condenses all the butanes, the hydrogen chloride going into solution. A small amount of uncondensable gas is vented from an accumulator handling the liquid. All condensate is charged to a stripping tower at the base of which a reboiler supplies heat for stripping, while a refrigerated condenser provides reflux from the overhead. This method effects very complete stripping of the bottoms product.

The overhead vapors from the stripping column are recycled to the inlet of the catalyst chambers. The heat of reaction is low so that no special equipment need be used to maintain the desired temperature for the reaction.

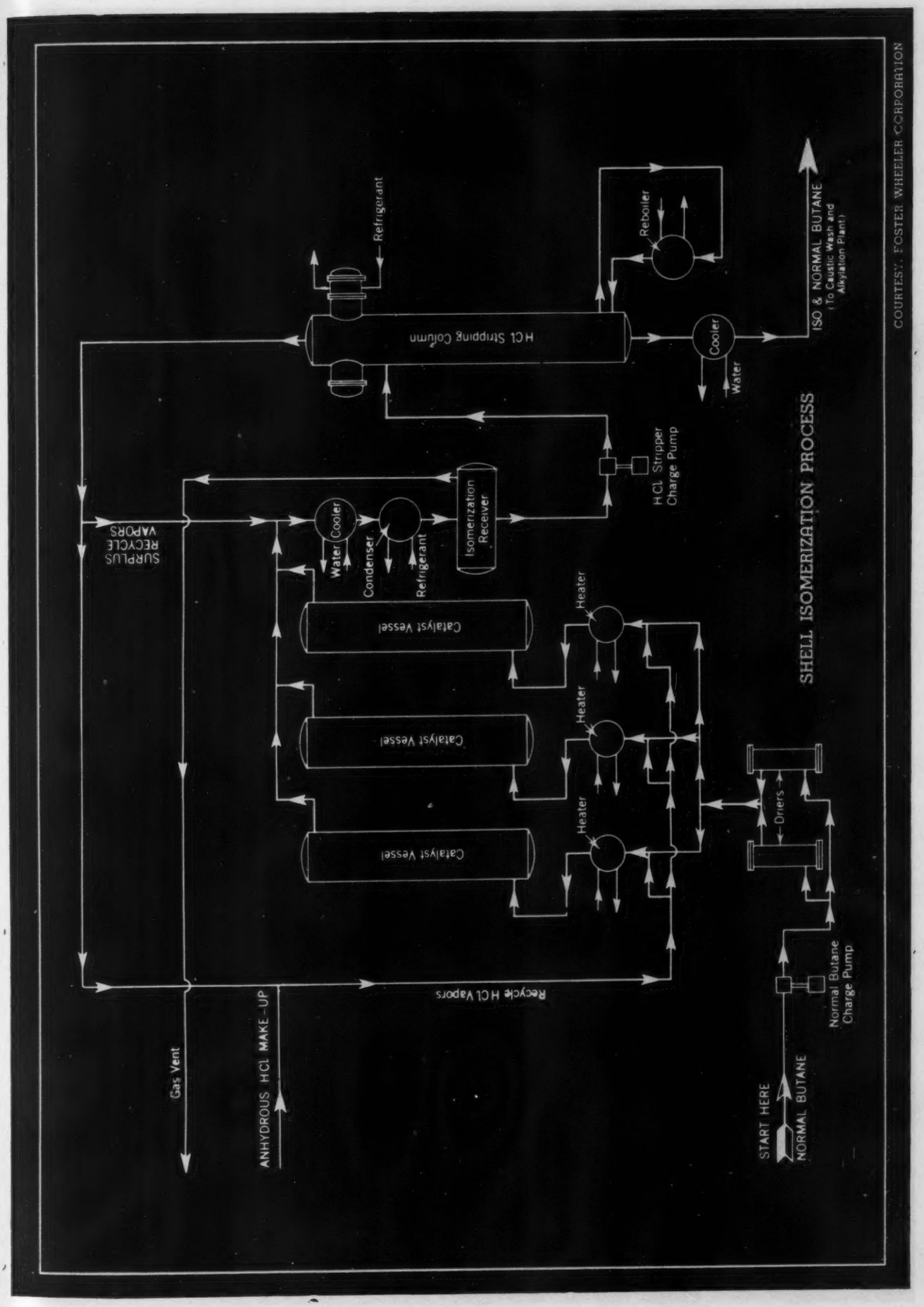
The accompanying flow sheet shows the features of a typical isomerization plant. The hydrocarbon charge is picked up by the charging pump and passed through drying vessels which extract the last trace of moisture. Flow is then divided in the desired proportions for the catalyst vessels; each individual stream receives its correct amount of hydrogen chloride recycle gas, and passes through preheaters where complete vaporization occurs.

The vapors pass through the catalyst beds and exit streams combine before flowing through coolers and condensers. The condensate is run to an isomerization receiver from which it is pumped to the HCl stripping column. Butanes, free from hydrogen chloride, flow from the base of the column while vapors, consisting largely of hydrogen chloride, are recycled either to the entrance to the catalyst chambers or directly to the isomerization receiver.

No special materials are required for the construction of the plant since dry hydrogen chloride, under the conditions prevailing in the process, is not corrosive. Temperatures and pressures under which the plant operates are moderate, consequently the required capital outlay is low.

The catalyst has been specially developed for the purpose. It is rugged, cheaply produced, and has long life; these factors combined make its regeneration unnecessary. The catalyst is resistant to poisons but it is necessary to reduce the proportion of olefins and pentanes in the charge stock to a low figure as both of these produce objectionable by-products and tend to shorten the life of the catalyst.

The process is licensed under patent rights of the Shell Development Company, San Francisco, California.


SHELL ISOMERIZATION PROCESS
COURTESY FOSTER WHEELER CORPORATION
START HERE
NORMAL BUTANE
Normal Butane Charge Pump
Driers
Heater
Catalyst Vessel
Heater
Catalyst Vessel
Heater
Catalyst Vessel
Recycle HCl Vapors
ANHYDROUS HCl MAKE-UP
Gas Vent
SURPLUS RECYCLE VAPORS
Water Cooler
Condenser
Refrigerant
Isomerization Receiver
HCl Stripper Charge Pump
HCl Stripping Column
Refrigerant
Reboiler
Cooler
Water
ISO & NORMAL BUTANE
(To Caustic Wash and Alkylation Plant)

Shell Phosphate Process

THE Shell Phosphate Process is a regenerative liquid purification system for the removal and recovery of hydrogen sulfide from gaseous and liquid hydrocarbons. The process consists essentially of two steps: absorption or scrubbing with a solution of tripotassium phosphate and regeneration of the spent solution. The principal absorption reaction is expressed

$$H_2S + K_3PO_4 \rightarrow KHS + K_2HPO_4.$$

Regeneration reverses this reaction.

The hydrogen sulfide recovered is essentially free of hydrocarbons and is an ideal raw material for the manufacture of sulphuric acid or elemental sulphur.

The inexpensive solution used is ordinarily prepared at the plant for commercial grades of potassium hydroxide and phosphoric acid in such proportion that the molal ratio of KOH to H_3PO_4 is between 2.95 and 3.00 to 1. The optimum concentration of K_3PO_4 depends upon the amount and nature of impurities in the hydrocarbon processed. Since K_3PO_4 is a stable inorganic salt, which does not decompose nor vaporize under treating conditions, solution loss is negligible, being confined to leakage at packing glands of pumps, etc. Such leakage can be collected and returned to the system. K_3PO_4 does not contaminate nor polymerize the hydrocarbon.

Iron and steel are satisfactory for all equipment. In case of corrosive cooling-water, Admiralty-metal tubes and Muntz-metal sheets and baffles may be used for condenser and solution cooler. Gages, instruments, valves and pumps should be all iron and steel. Monel or stainless-steel trim can be used. Observance of these general specifications will insure freedom from corrosion on the process side.

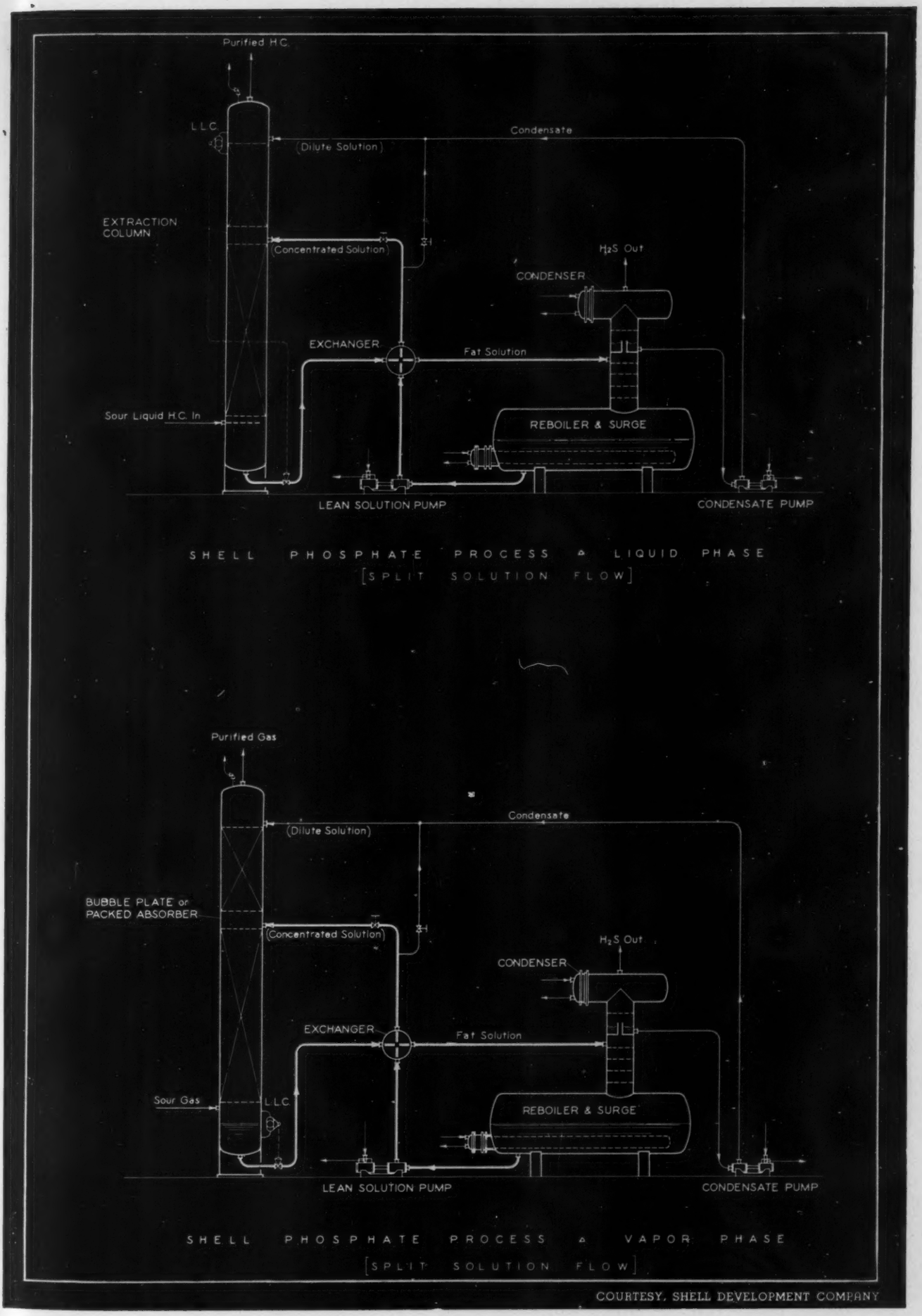
The accompanying flow diagrams indicate the necessary equipment. Gases are scrubbed in a countercurrent absorber of bubble-plate or packed-tower construction. The hydrogen-sulfide content of gases can be reduced low enough to satisfy any reasonable refinery requirement. Treatment at temperatures as high as 200° F. is possible with the Phosphate Process. The equilibrium vapor pressure for a given solution saturation is appreciably less over dilute than over concentrated solutions. Advantage is taken of this property of phosphate solution by using a split solution flow in the absorber. The bulk of the H_2S is absorbed in the lower section with full strength K_3PO_4, and the more difficult removal of H_2S from the already partially purified hydrocarbons is done in the upper section by a relatively dilute solution composed of all condensate and a small portion of regenerated solution.

Equilibrium of tripotassium phosphate with liquid hydrocarbons is even more favorable than with gases. A hydrogen sulfide content of treated propane-butane mixtures as low as 0.005 mol percent is not unusual. The split-solution-flow principle is applicable also to liquid phase extraction.

Regeneration of spent solution is ordinarily accomplished in a standard reboiler which can be heated with exhaust or other low pressure steam. The vapor evolved, H_2S and steam, is condensed and cooled; the condensate is stripped and returned to the top of the absorber or to the regenerated solution direct to maintain proper concentration; and hydrogen sulfide is vented to special usage or suitable disposal. The concentrated solution falls by gravity to a surge tank where residence at the boiling point causes further regeneration. Heat economy is realized through use of exchangers on the solution to and from the reboiler. Direct-fired regeneration is also possible in this process. Thus a phosphate plant can be installed without increasing existing steam generation facilities. Stripping with steam is another successful method of regeneration.

Operating and maintenance costs are low. Full automatic control is possible, so that only part of an operator's time is required for general supervision. Occasional laboratory analyses serve to indicate proper operation. As was mentioned above, corrosion problems are practically non-existent.

The process is licensed by Shell Development Company, San Francisco. Shell Development Company furnishes special instructions for preparing the solution and operating the plant, including a detailed discussion of analytical methods for chemical control.



COURTESY, SHELL DEVELOPMENT COMPANY

Sulphuric Acid Alkylation Process

ALKYLATION in its present commercial form is a process employing concentrated sulphuric acid as the catalyst to promote the alkylation of isobutane with butylenes and amylenes. The importance of this process is its ability to produce greater quantities of 100 octane aviation gasoline from a given quantity of olefin and at less cost than any other process available to the industry.

Considerable advances in the technique of alkylation have taken place during the past year, and it is now possible to produce an alkylate of at least 95 octane ASTM, suitable as the major blending component of 100 octane aviation gasoline.

The octane number of the alkylate produced from amylenes is somewhat lower than that produced from butylenes. The following data applies only to the yields from butylene alkylation. The type of plant is similar whichever of these olefins is processed.

The feed stock for an alkylation plant consists of the butane-butylene fraction from a cracking or dehydrogenation operation plus additional iso-butane from natural gas or from isomerization of normal butane. Physical characteristics of the hydrocarbons normally occurring in the feed stock are as follows:

COMPOUND	Specific Gravity	Atmos. Boiling Point °F.	Lbs./Sq. In. Vapor Pressure at 100 °F.
Iso-butane	0.565	12	73.7
Iso-butylene	0.603	20	63.5
Butylene 1	0.601	21	61.5
Normal Butane	0.585	33	52.2
Butylene 2	0.613	34 Cis. 36.5 Trans.	50.0

In order to produce crude alkylate satisfactorily it is necessary that the ratio of iso-butane to the sum of the unsaturated hydrocarbons, i. e., of iso-butylene, butylene 1 and butylene 2 shall never be less than about 1.2 by weight.

The catalyst that promotes the reaction is commercial concentrated sulphuric acid of the following strength:

To the Unit	From the Unit
100	88 - 91.0

A typical yield of crude alkylate consists of two groups of constituents having characteristics and proportions as follows:

		Liquid Volume Percentage
No. 1 Fraction:		
Light Alkylate:		
Gravity, Degrees A.P.I.	68–69	96.0
Octane Number, A.S.T.M.	95	
A.S.T.M. Engler Distillation:		
10 percent	195 °F.	
50 percent	224 °F.	
90 percent	237 °F.	
Reid V. P.	3.5—4.0 lb.	
No. 2 Fraction:		
Heavy Alkylate:		
Gravity, Degrees A.P.I.	48–52	4.0
Octane Number, A.S.T.M.	80–85	

This alkylate meets aviation gasoline standards with respect to acid heat, bromine number and sulphur content. Blending the No. 1 fraction with selected straight-run aviation stock in proportion to give 86 octane number and adding 3 cc. lead gives aviation gasoline 100 octane number A.S.T.M.

The flow sheet on the opposite page shows a typical layout of the equipment employed in the process. The plant represented here comprises the following main operating units:

(1) Alkylation mixing section which includes suitable equipment to provide the proper mixing contact and settling time. Several identical mixing sections may be used arranged either for series or parallel flow of the charge material. Only one mixing section is shown in the flow sheet for the sake of simplicity.

(2) Alkylate debutanizer composed of equipment to separate between alkylate and the residual butanes.

(3) Alkylate rerun tower with suitable equipment to separate the desired light alkylate from the heavy alkylate.

(4) Depropanizer tower with suitable equipment for continuous elimination of propane which is included in the charge stocks.

(5) Isobutane fractionator which is a combination of equipment to separate iso and normal butane.

As the olefin containing charge stock enters the mixing section, it is joined by recycle stock from the overhead of the isobutane fractionator. The combined stream is then joined by an internal recycle containing sulphuric acid and the chemical reaction takes place. The reaction is exothermic and provision must be made to dissipate the heat evolved. To eliminate the heat generated by the chemical reaction, the mixture is passed into a chiller, then enters the reactor in which a suitable pressure drop is maintained in order to keep the liquid in a homogeneous state.

Leaving the reactor the stream is split in two directions. A portion passes into the suction of the recycling pump where it is joined by a portion of spent acid, a portion of fresh sulphuric acid, and the combined hydrocarbon stream described above.

The remaining portion of the stream leaving the reactor enters a separator where the acid and hydrocarbon phases are separated. Most of the acid is returned into the suction of the circulating pump while a small part of the acid is withdrawn from the system.

Crude alkylate mixed with butanes are withdrawn from the separator and washed with caustic soda in a scrubber in order to counteract any acidity caused by a possible acid carry-over.

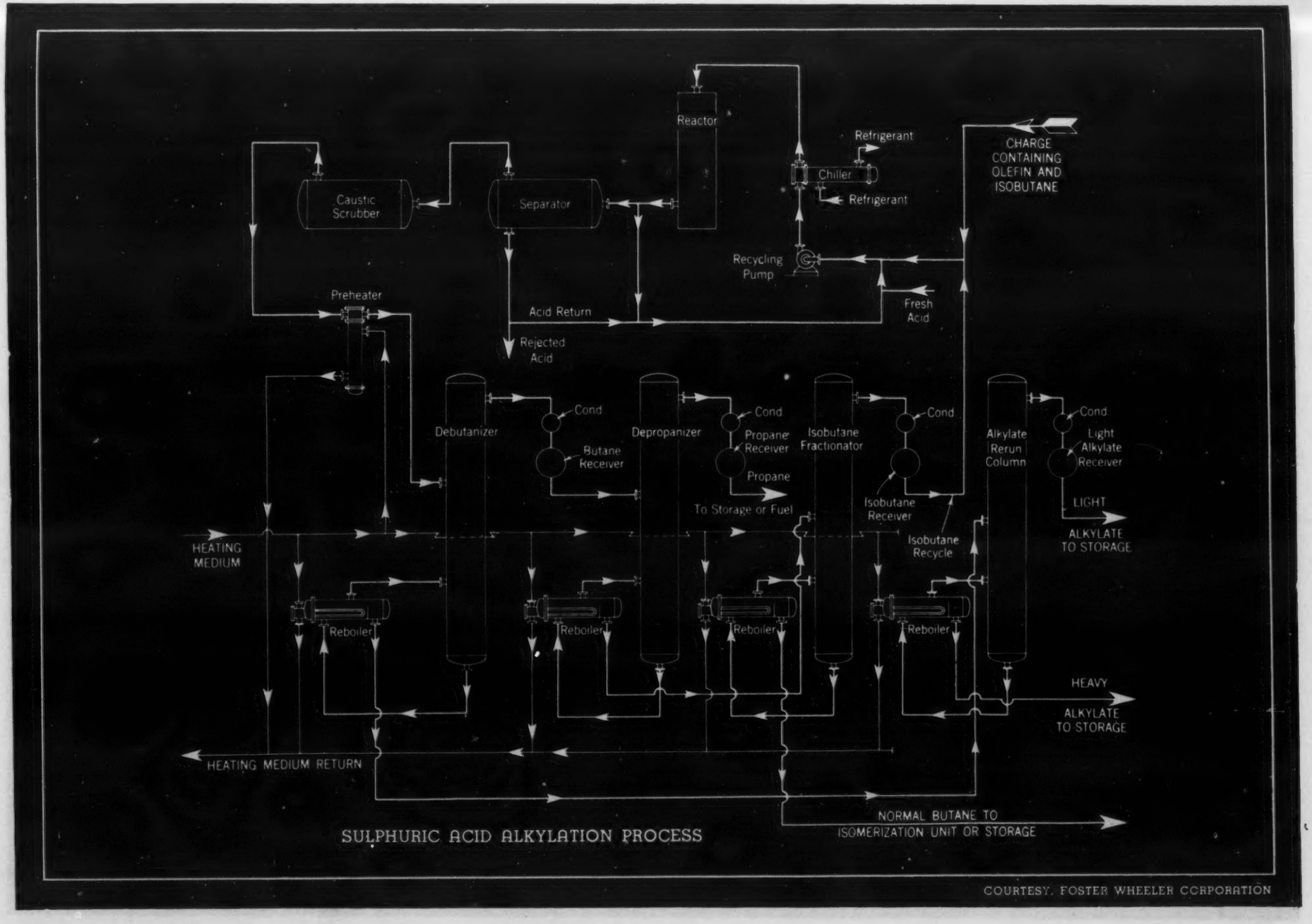
This neutralized hydrocarbon is withdrawn and sent to the debutanizer. The overhead from the debutanizer consists of iso-butane, normal butane and any propane that may have been present in the original charge. The overhead is totally condensed and pumped to the depropanizer in order to eliminate propane from the system. The bottoms from the depropanizer are piped to the isobutane fractionator.

The isobutane fractionator separates the iso and normal butane. Normal butane is withdrawn from the bottom and the iso-butane is taken overhead and recycled back to the mixing section as described.

Bottoms from the debutanizer tower consisting of the debutanized crude alkylate flow into the alkylate rerun column. In this column light alkylate is segregated and taken overhead ready for blending with straight run gasoline and tetraethyl lead to form 100 octane aviation motor fuel. Heavy alkylate is withdrawn from the bottom of the alkylate rerun column. This may be blended into general motor fuel production.

The alkylation process was developed almost simultaneously by several companies which have arranged for the licensing of the process to others by the Universal Oil Products Company.

Foster Wheeler Corporation offers the complete engineering, fabrication, and construction of the process.



SULPHURIC ACID ALKYLATION PROCESS

COURTESY, FOSTER WHEELER CORPORATION

TVP Process

THE new TVP process as it has been developed during an extensive research program over the past two years in the experimental semi-commercial plant and laboratory of Petroleum Conversion Corporation at Elizabeth, New Jersey, is shown on the opposite page, as it is adapted for naphtha reforming.

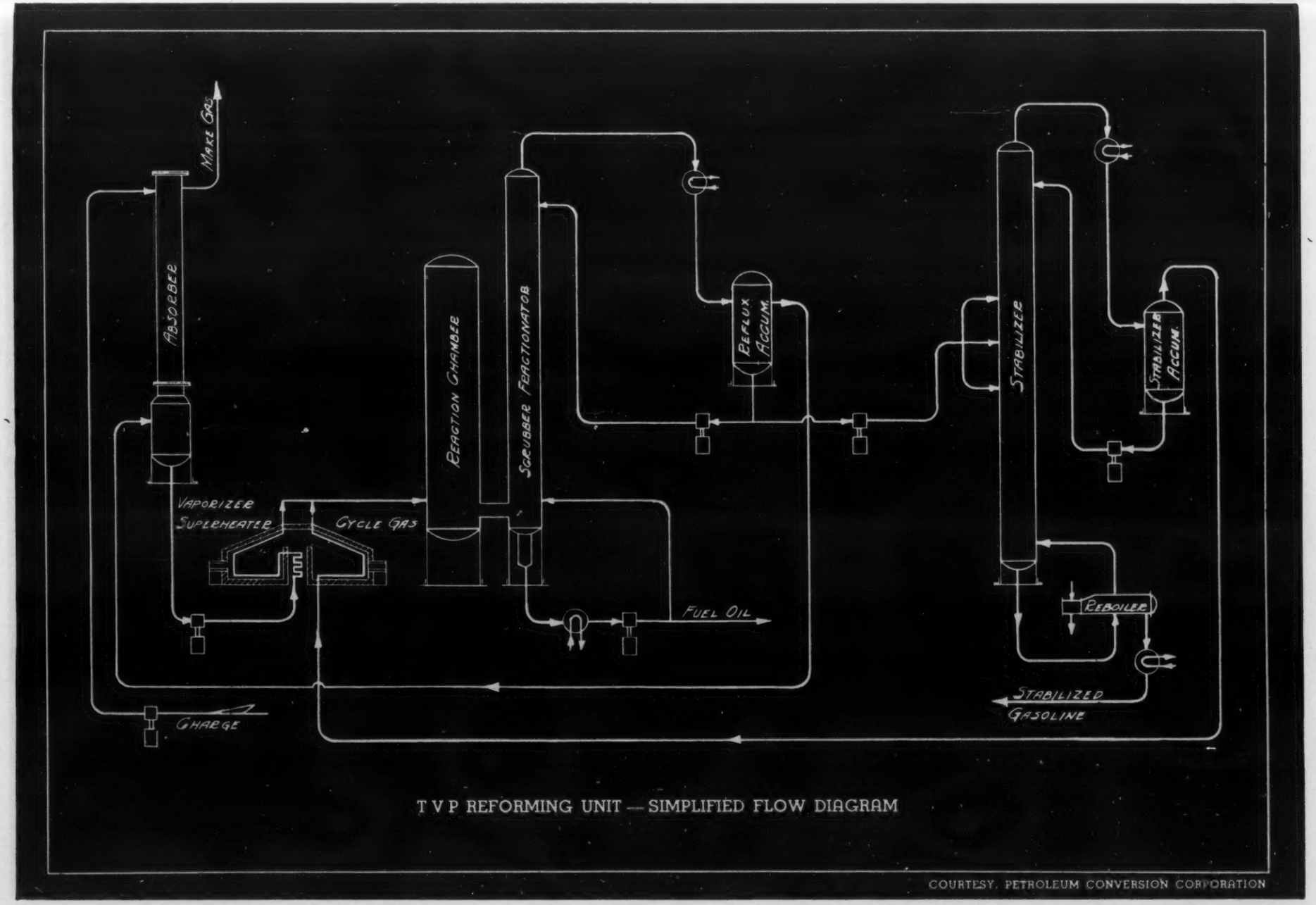
Commercial results are now available from this new TVP process and demonstrate that substantial increases in total yield and product quality have been attained. Closer control of the several factors in the vapor-phase thermal cracking reaction together with effective thermal treatment of recirculated selected fractions of produced or added gases have been mainly responsible for the improvement thus far demonstrated. Further simplification of the process design has resulted in significant reductions in investment and operating costs.

Reference to the flow diagram will show that the simplification here referred to has been accomplished without sacrifice of the basic principle of the TVP process, which is the application of heat for cracking the superheated vapor by admixture with highly heated gases. In the TVP process the feed stock is sent to the heater by way of an absorption tower, operating at plant pressure, counter-current to the effluent by-product gases. The enriched feed-stock is heated in a single coil to a temperature slightly below the optimum required for the reaction and is then commingled with the highly heated gases from the gas-pyrolysis coil. The resulting mixture is passed through the reaction chamber; the quantities and temperatures of the gases and vapor having been previously established to give the desired reaction time and temperature.

When the process is adapted for heavy-oil cracking the enriched heavy feed stock from the absorber is first heated and flashed in an evaporator to remove tars, after which the resulting vapor is superheated and commingled with the heated gases as shown. The presence of the dissolved gases in the heavy feed stock greatly facilitates the flashing operation. After leaving the reaction chamber the gases and reaction products enter the fractionating column where the cracked residuum is removed at the bottom, the gasoline and gases distilling over the top in the usual fashion. In recycle operation, a side cut is taken off the column to be reheated and returned to the reaction zone. In the condensing equipment, the temperature of the gases and gasoline is reduced approximately to atmospheric and equilibrium separation takes place at plant pressure in the accumulator. The gases from this accumulator are vented to the absorber for stripping before emerging from the system as by-product gas. The liquid phase from the accumulator, containing a substantial quantity of gases lighter than butane, is fed to the stabilizer whence the stabilized gasoline is withdrawn to storage. The gaseous overhead from the stabilizer, mostly butanes and propane with their corresponding olefines, is returned to the gas-pyrolysis coil for further treatment.

Where additional gaseous fractions over the quantity produced by cracking are available from extraneous sources, provision may be made for introducing these along with the recirculated gases into the gas-pyrolysis coil. In this connection, it has been found that when it is desired to blend light, unstabilized naphthas with the product from the cracking operation, a distinct advantage in octane number of the blend may be obtained by co-stabilizing the two materials in the cracking-unit stabilizer so that any excess light fractions may be returned to the gas-pyrolysis coil along with the recirculated gases. Further, an appreciable and profitable increase in over-all efficiency may be obtained when provision is made to collect the gases normally vented from topping-still operation. These gases usually contain substantial quantities of butane and lighter which may be sent to the cracking-unit gas pyrolysis coil to yield additional gasoline fractions.

Complete data from the semi-commercial evaluation of a large number of feed stocks as well as full records of commercial operation of the new TVP process are now available to the industry. Inquiries will be given prompt attention by Petroleum Conversion Corporation, sole owners of the patents covering the new TVP process, Elizabeth, New Jersey.



T V P REFORMING UNIT — SIMPLIFIED FLOW DIAGRAM

COURTESY, PETROLEUM CONVERSION CORPORATION

Catalytic Polymerization Process

THE U.O.P. catalytic polymerization process produces a new kind of high-octane gasoline from gases which are a by-product of cracking operations. Its utility extends over a very wide range. It is profitable for large and small refiners. The largest U.O.P. poly unit is processing 27,000,000 cubic feet of gas a day; the smallest about 125,000. This information is presented here through the co-operation of Universal Oil Products Company of Chicago.

Midget poly plants have become a factor of great importance to the smaller refiners. A number have been built in the past two years, or are now under construction, to operate in conjunction with Dubbs cracking units. They are built at low cost and their earnings pay them out very quickly. A poly unit in a small refinery was built at a cost of less than $10,000 and paid for itself in the first 30 days of operation.

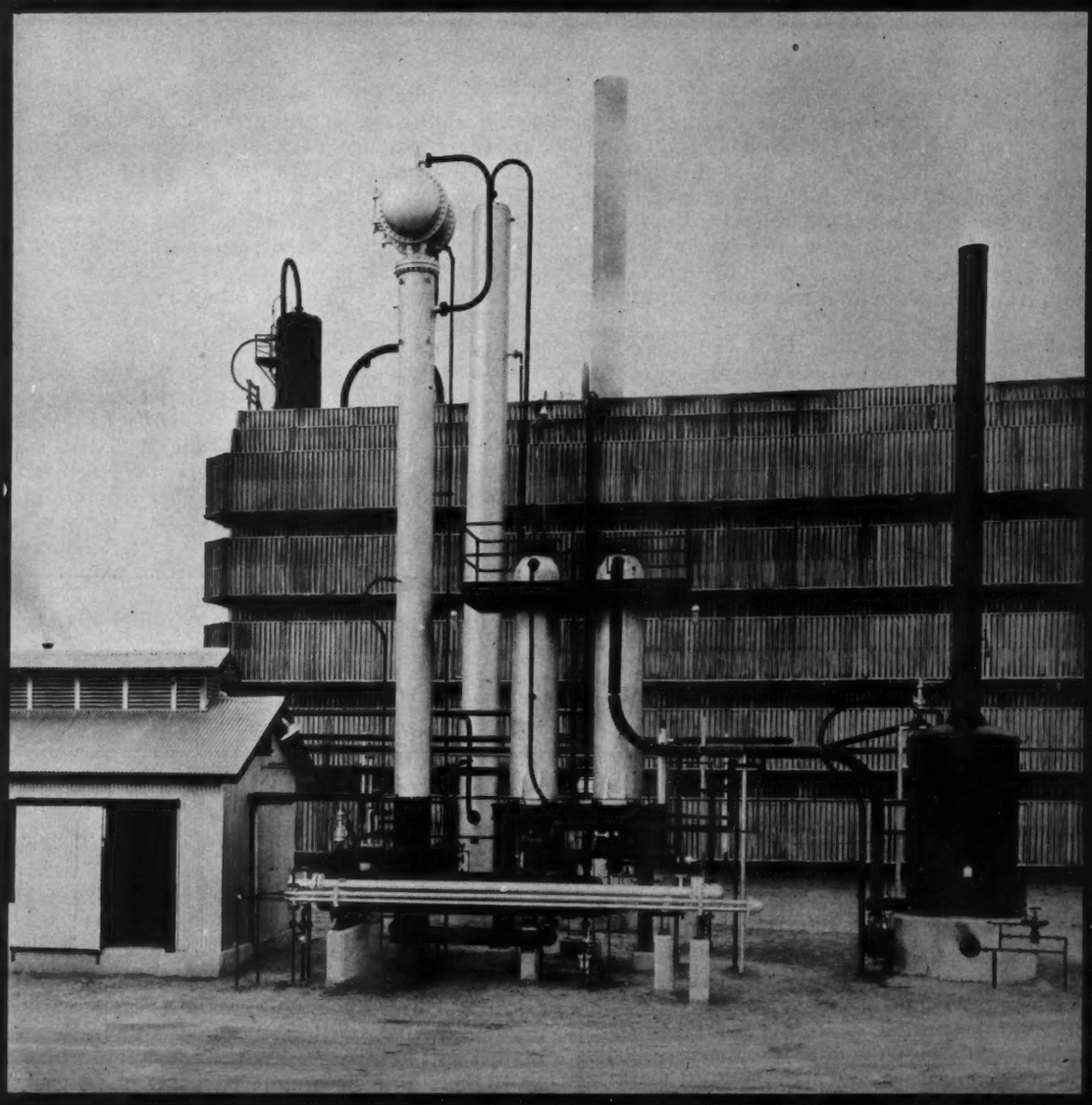
The U.O.P. catalytic polymerization process can do four important things for the refiner: (1) Increase gasoline production by 2 to 5 percent without increased crude supply. (2) By blending his output of polymer gasoline with part of his Dubbs cracked gasoline, he can produce a fuel of premium octane rating, which has a high merchandising and advertising as well as service value. (3) By blending his polymer gasoline with all his Dubbs cracked gasoline, the endpoint of his gasoline can be raised 15° to 25° F., without decreasing the overall octane number. This means increasing his gasoline yield by about 2 percent and increasing the capacity of his Dubbs units by 10 to 15 percent. (4) If "Q" gasoline is sold the refiner can cut his lead bill by reason of the high blending value of his polymer gasoline.

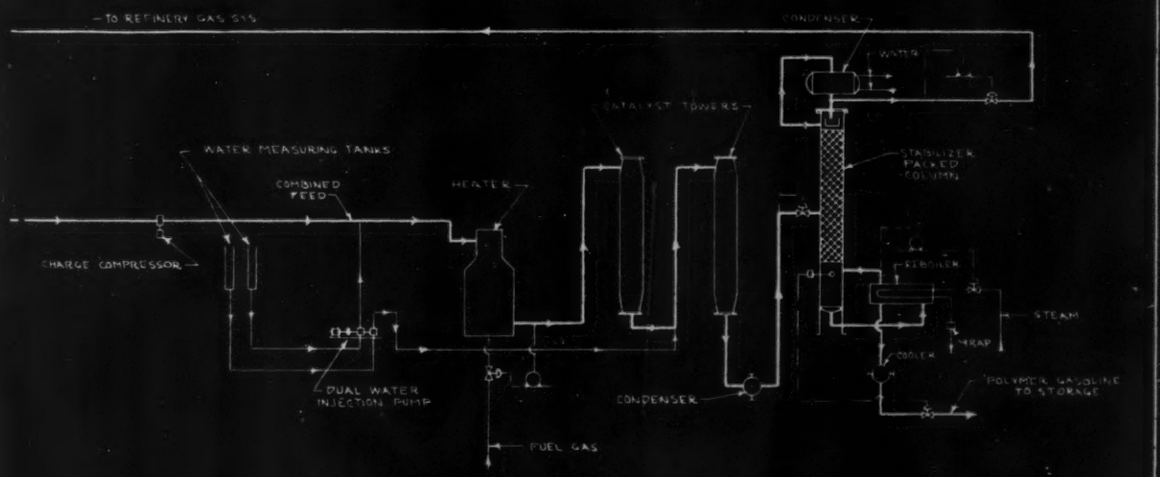
The yield of polymer gasoline depends on the percentage of heavy olefinic gases, such as propene and butenes, in the cracked gas processed. As an example, the average yield of this type of gasoline when processing Dubbs cracked stabilized gas is from five to six gallons per 1000 cubic feet. However, where the olefinic content of the gas treated is higher, proportionately higher yields of polymer products are obtained.

Since polymerization is the combination of olefins to form larger molecules it is apparent that saturated substances (paraffins) do not yield polymers. On the other hand, saturated hydrocarbons may be catalytically dehydrogenated or cracked to olefins. Thus, in order to produce gasoline from normally gaseous olefins, one reaction takes place—polymerization. In order to produce gasoline from normally gaseous paraffins, two reactions take place—one a cracking or dehydrogenation, the other polymerization. It should be pointed out that to produce olefins from paraffins, high temperature must be used, while polymerization of olefins is favored by low temperatures. To crack paraffin gases and polymerize the olefins formed calls for opposing reactions, and therefore the conditions best suited for olefin formation are not suitable for the polymerization reaction. From a theoretical and practical standpoint it is best to produce the olefin gases under optimum cracking or dehydrogenating conditions and then convert the olefins to liquids under the conditions most suitable for their polymerization. The catalyst employed in the U.O.P. catalytic polymerization process has a long life, it is not impaired by hydrogen sulfide and can be regenerated in place by a simple air-burning operation at infrequent intervals when and if this is necessary. In the new units regeneration is unnecessary.

A further development of catalytic polymerization is the U.O.P. isooctane process which produces motor fuel of 96 octane number. This fuel is useful in increasing the power output per unit weight of motor and as a result is a valued aviation fuel.

A typical flow chart of the process is shown on the opposite page, together with a photograph of a commercial U.O.P. polymerization plant, the rated capacity of which is 500,000 cubic feet per day.





U.O.P. CATALYTIC POLYMERIZATION PROCESS

COURTESY, UNIVERSAL OIL PRODUCTS COMPANY

U. O. P. Isooctane Process

A COMMERCIAL plant is described which treats butane-butene mixtures selectively to polymerize the normal and isobutenes contained therein, the plant having a daily capacity of 1800 barrels of butane-butene fraction, from which is produced 460 barrels of isooctenes. These isooctenes are catalytically hydrogenated to isooctanes, the latter having octane ratings of from 93 to about 97, dependent upon the conditions under which the octenes are produced.

Three such units are now operating and more are projected. This isooctane process is assuming greater importance in view of increasing demand for high octane number fuels, particularly aviation fuel.

The catalytic production of isooctenes from the normal and isobutenes present in cracked gases is being carried out commercially under relatively mild conditions. The isooctenes produced are hydrogenated into isooctanes with values ranging as stated above. These octane ratings can be controlled as a function of the percentage of normal and isobutene present in the charge and of temperature, and to a lesser extent of time and pressure used in polymerization. The higher the octane rating, the lower the yield of isooctanes per barrel of the butane-butene processed.

The process of producing isooctanes by the catalytic polymerization reaction (U.O.P. Catalytic Polymerization Process), uses as a charging stock the butane-butene (BB) fraction from the stabilizer producing cracked gasoline of the vapor pressure desired. The BB fraction contains 15 percent of isobutene, 30 percent of normal butene, and 55 percent of normal and isobutenes. A flow chart of the Isooctane Process is shown on the opposite page through the co-operation of Universal Oil Products Company, Chicago, Illinois.

The liquid butane-butene charge is passed through a caustic-soda scrubber to reduce the percentage of the sulfur components present. The treated material is then pumped through a preheater heated by steam generated by the process, wherein the temperature is raised to about 300 to 350° F., under a pressure of about 600 to 800 pounds. The BB fraction then passes through a "solid phosphoric-acid" catalyst, wherein the exothermic heat of the reaction is controlled by boiling water, the temperature of which is controlled by varying the steam side pressure, and the desired temperature is maintained during the polymerization. Dependent upon the time-temperature conditions prevailing and the percentage of normal to isobutane present in the charge their combination takes place in varying proportions.

The polymer product is then passed to a tower where a separation of the polymer and butane is made, after which it is fractionated into the isooctenes (dimers) and the dodecenes (trimers). In general, the percentage of isooctenes in the polymer product is about 88 to 90 percent, the balance being trimers. As an example of performance, a 30 percent conversion of the above stock to polymer can be effected. This is when producing isooctenes on the basis of a charge of 2:1 ratio of normal to isobutene. The isooctene fraction which boils between 200 and 260° F., and has an 83 octane number, is hydrogenated to isooctanes of 96 octane rating. The commercial unit described when processing 1800 barrels of the butane-butene fraction then produces 380 barrels of isooctenes and 47 barrels of trimers. The isooctenes are converted into isooctanes by catalytic hydrogenation.

The isooctanes being produced commercially have a boiling range of 200 to 260° F. and, therefore, are not a complete motor fuel as to volatility. They require blending with hydrocarbons, such as those of the aviation-gasoline boiling range or isopentane, or isohexanes, in order to give volatility to the fuel.

In some cases isopentane is blended with isooctane and straight-run gasoline to provide required front-end volatility to the isooctane. The volume of isopentane is generally restricted to about 15 percent. The results of blending 96 isooctane fuel, 74 octane aviation straight-run of 7 pounds Reid vapor pressure, and isopentane with 3 cc. of tetraethyl lead to produce 100 octane fuel are shown in Table 1.

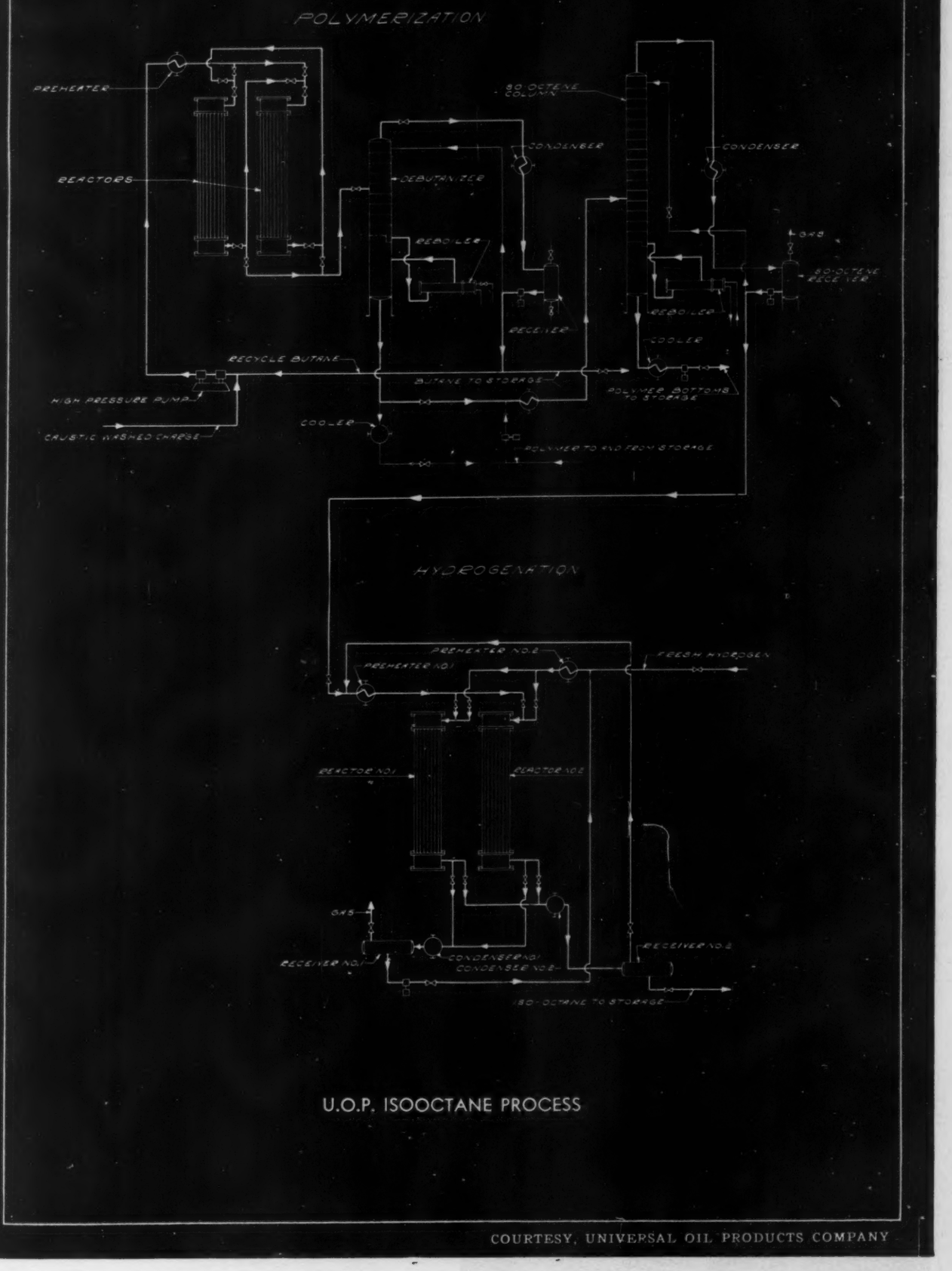
TABLE 1

Composition of 100-Octane Fuel Containing 3 cc. Tetraethyl Lead Per Gallon

Isopentane (Percent)	Aviation Gasoline (Percent)	Isooctane (Percent)	Reid Vapor Pressure (Lb. per Sq. In. at 100° F.)
0	38.0	62.0	4.0
10	37.2	52.8	5.8
17	36.7	46.3	7.0
20	36.4	43.6	7.7
30	35.7	34.3	9.5
40	34.9	25.1	11.4
50	34.1	15.9	13.3

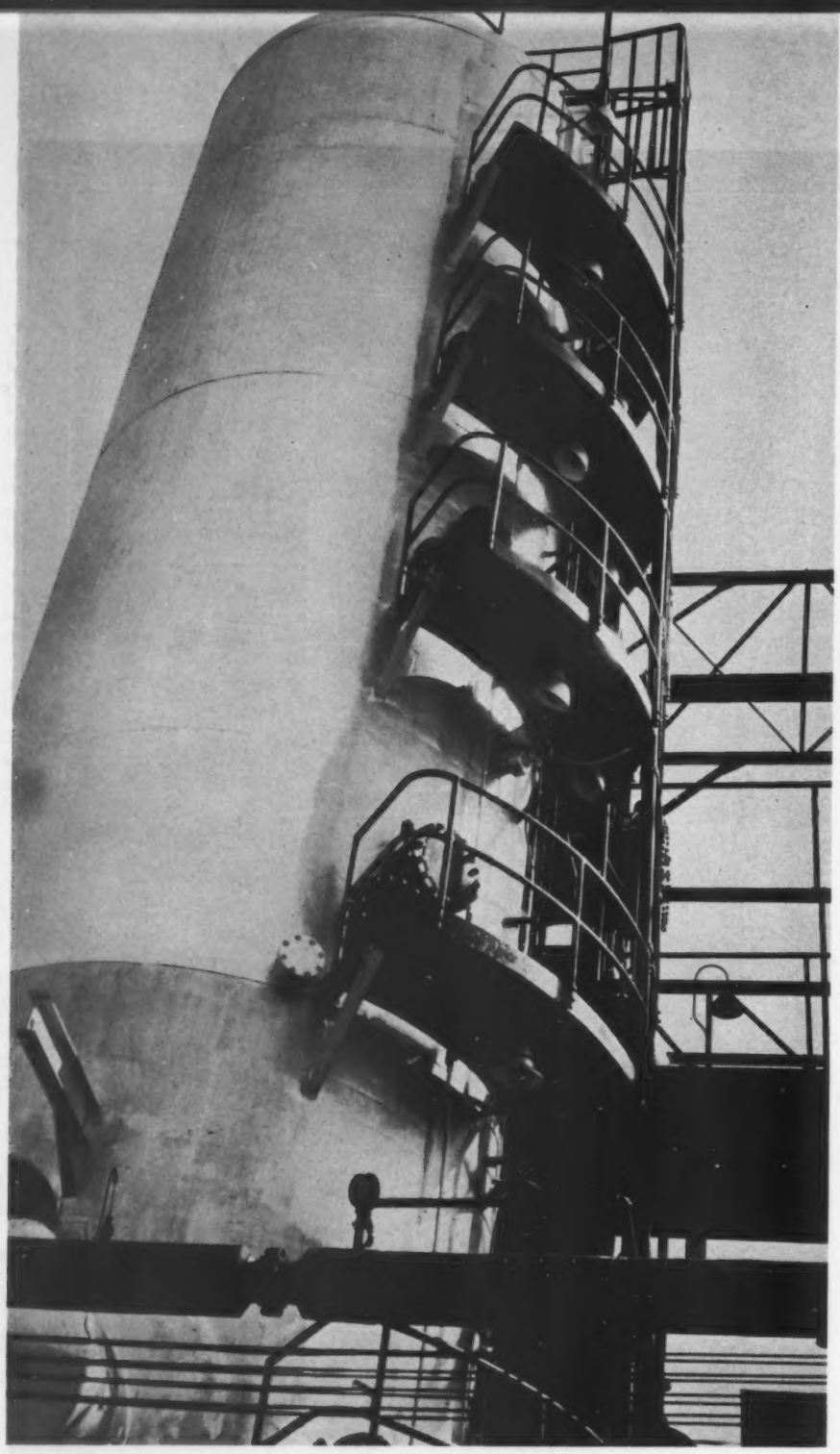
The importance of isooctane in aviation fuel has been established for special uses such as military aviation and high-revenue transport. It may be readily predicted that within a short time all passenger planes will be operated with motor fuel of 100 octane or higher. The dominant position of polymerization in the economy of motor fuel production is also definitely established in that small amounts of polymer gasoline may be used to correct an octane deficiency in the gasoline production of the refinery, and thus function to balance the quality of motor fuel produced.

The foregoing is based on a paper "Motor Fuels from Polymerization," by Gustav Egloff, J. C. Morrell and Edwin F. Nelson, Universal Oil Products Company, which was presented before the American Petroleum Institute, Division of Refining, November 11, 1937, and presented in full in The Refiner, Vol. 16, No. 11, November, 1937, page 497, and on operation results obtained since that time. The complete paper describes three modifications of the polymerization process: a, polymerization of hydrocarbon gases containing propene and butene; b, pyrolitic cracking of butanes (and also propane) to produce olefin hydrocarbons followed by catalytic polymerization to produce polymer gasoline; c, selective polymerization of normal and isobutene and hydrogenation of the resulting octanes into isooctanes, this latter process being chiefly described above.



U.O.P. ISOOCTANE PROCESS

COURTESY, UNIVERSAL OIL PRODUCTS COMPANY



When the fractionating column was designed especially for the rerun unit, heating coils were provided for each of the six stripping trays. This resulted in fouling so a bundle of tubes was installed near the base of the tower as a reboiler.

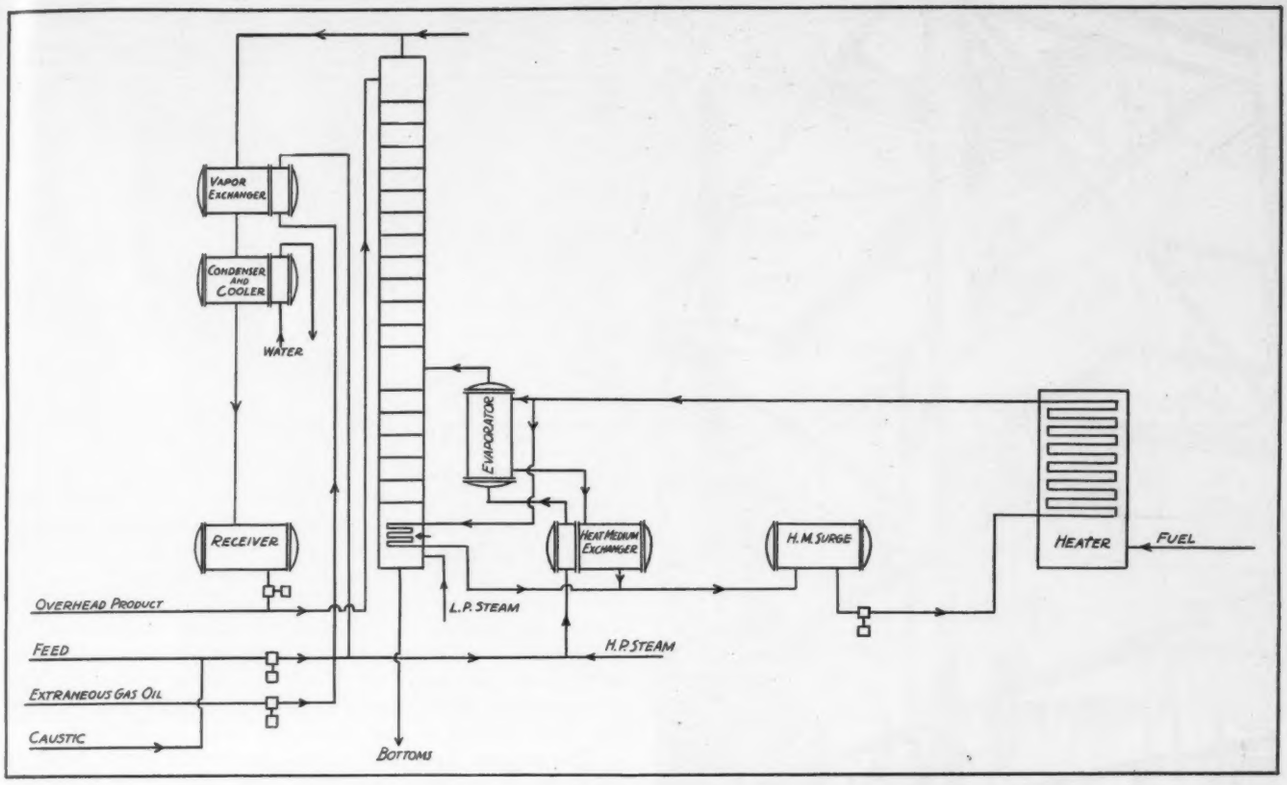
This permits a portion of the heat medium to work under controlled conditions.

The column is 13 feet in diameter, 48 feet and 6 inches high, has 12 bubble trays and six stripping plates with manholes for each tray.

Rerun Unit Designed to Operate with Heating Medium and Exchangers

RICHFIELD OIL CORPORATION has designed a special unit for rerunning acid-treated pressure distillate produced by cracking at the Watson, California, plant. This rerun plant includes portions of a crude distillation plant which could be adapted to rerunning.

A departure from the conventional distillation practice is in the method of evaporation. Instead of charging the distillate to direct-fired tube stills, an enclosed system was developed through which a separate heating medium is circulated at controlled temperature and volume, using shell-and-tube exchangers in con-



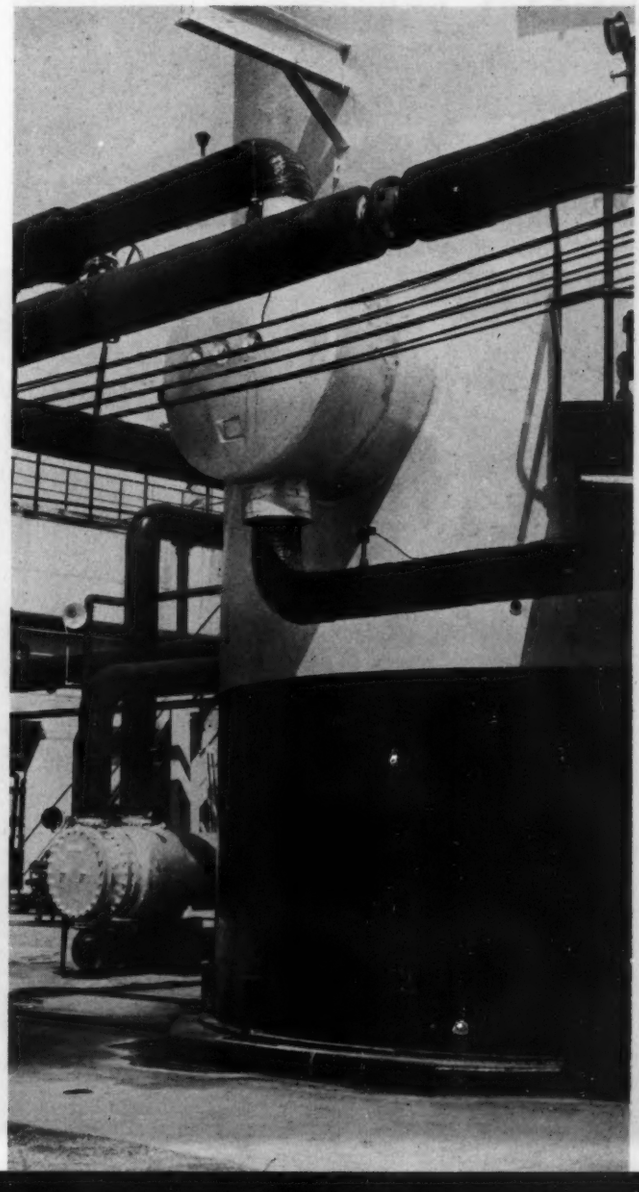
Flow diagram of the special rerun unit of Richfield Oil Corporation, Watson, California.

junction with the heat medium circuit and fractionating column to evaporate the pressure distillate.

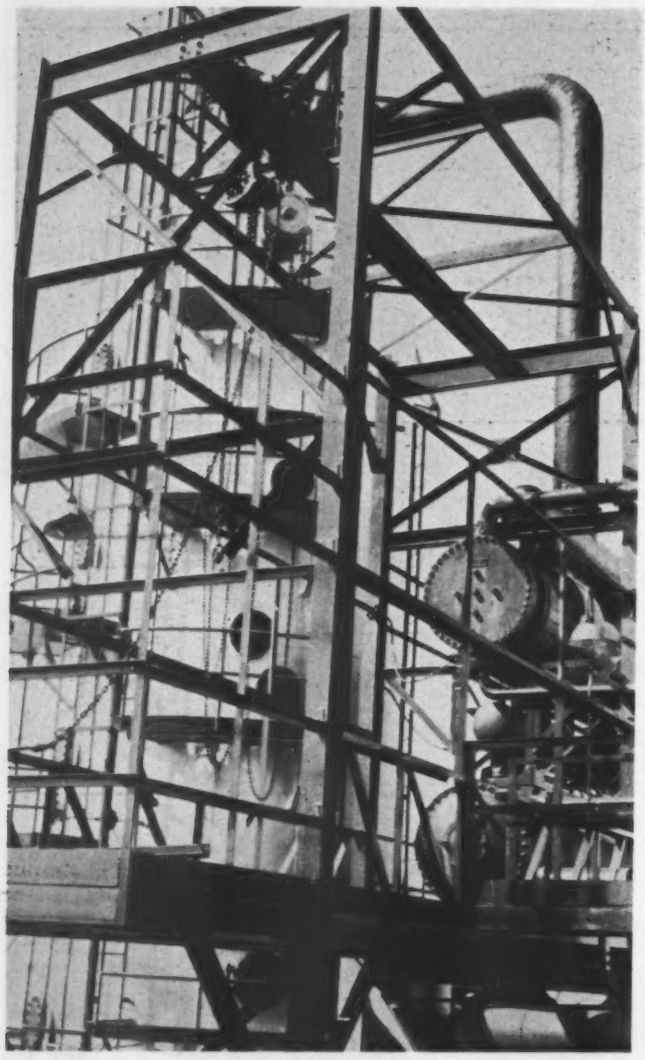
The fractionating tower was designed especially for rerunning the pressure distillate. It is 13 feet in diameter and 48 feet, 6 inches high, equipped with 12 fractionating bubble trays and 6 stripping plates, all of which are installed on 24-inch spacing, and has clean-out manholes at each tray. The 18-inch vapor line at the overhead outlet is flanged directly to a shell-and-tube vapor-to-charge exchanger which contains 1720 square feet of tube surface. Two heat medium exchangers heat the feed to the column, the first having 710 square feet, and the second 1500 square feet of tube surface. The second exchanger is located in a vertical position close to the tower with a single pass through the tubes to permit of nearly complete vaporization of the feed without excessive pressure drop.

The heat medium is a 32-33° A.P.I. gas oil, which is picked up from a 9 feet by 12 feet horizontal surge tank by a steam-turbine-driven centrifugal pump, and discharged with a pump pressure of 60 pounds per square inch to direct-fired tube stills in which about 40,000,000 Btu. per hour are liberated. The outlet, or transfer line of the heat medium heater is maintained at 610° F. and the pressure of 48 pounds per square inch to the various exchangers included in the heating circuit.

The feed to the plant is pumped at a uniform rate of 380 barrels per hour, using centrifugal pump driven by a steam turbine. A 4-inch feed line leads the pressure distillate at a temperature of 68° F. to



Heating unit tube bundle in base of column, which replaced individual stripping plate heating coils.



Laboratory Data

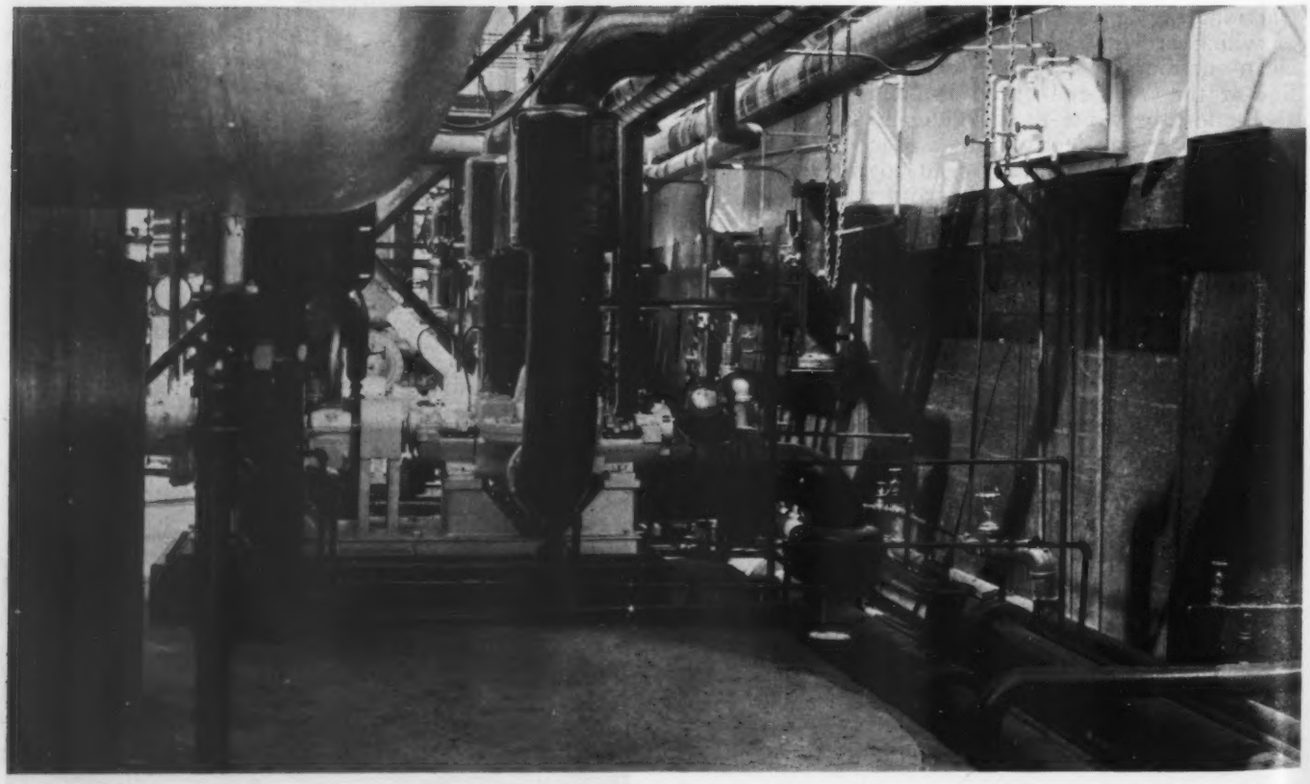
	Feed	Overhead	Extraneous Gas Oil	Gross Bottoms
API Gravity	47.4	48.6	32.6	26.6
Initial	214	210	440	438
10 percent	253	251	469	466
20 percent	266	262	482	479
30 percent	276	274	492	490
40 percent	288	285	502	502
50 percent	301	299	516	515
60 percent	317	313	532	531
70 percent	334	328	551	551
80 percent	351	345	574	576
90 percent	377	366	605	609
95 percent	405	382	....	....
E. P.	462	400	669	669
Percent Sulphur	0.49	0.32	....	2.88
Percent RSH Sulphur	.015	.020	....	....
Color	Brown	30+	....	....
Octane No. MM	66.7	66.9	....	....
Cu Dish Gum	733	20	....	....
Gl. Dish Gum	450	2	....	....
Plant Yield	....	97.3%	....	....
Lab. T.B.P. Yield	....	97.3%	....	....

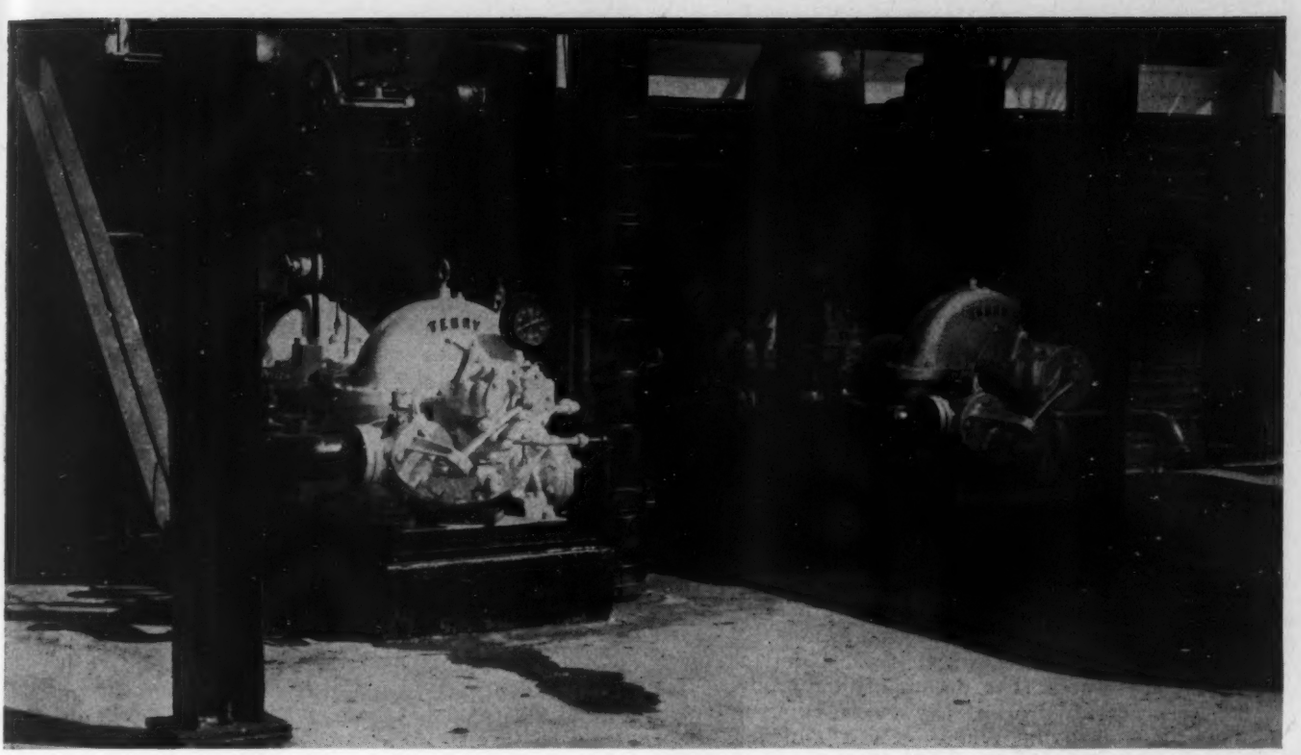
the vapor-to-charge exchanger where the temperature is raised to 192° F. From this exchanger, the charge passes through the two heat medium exchangers after which it enters the fractionating column. The temperature of the pressure distillate leaving the two exchangers is 280° F. and 363° F., respectively. With the charge of pressure distillate is included 12 barrels per hour of gas oil as extraneous feed, and 8 gallons per hour of 15° Be. caustic solution. Approximately 1500 pounds of steam is introduced into the feed ahead of the head medium exchangers.

The tower originally was equipped with heating coils on each stripping tray, but fouling of the coils by a deposit of foreign matter as a hard coke resulted in a fairly rapid drop in the heat transfer co-

Shell and tube heat exchange units in the distillate condensing section (left) are equipped with trolley and overhead track for cleaning and repair.

General layout of piping in the distillate rerun unit is shown below.





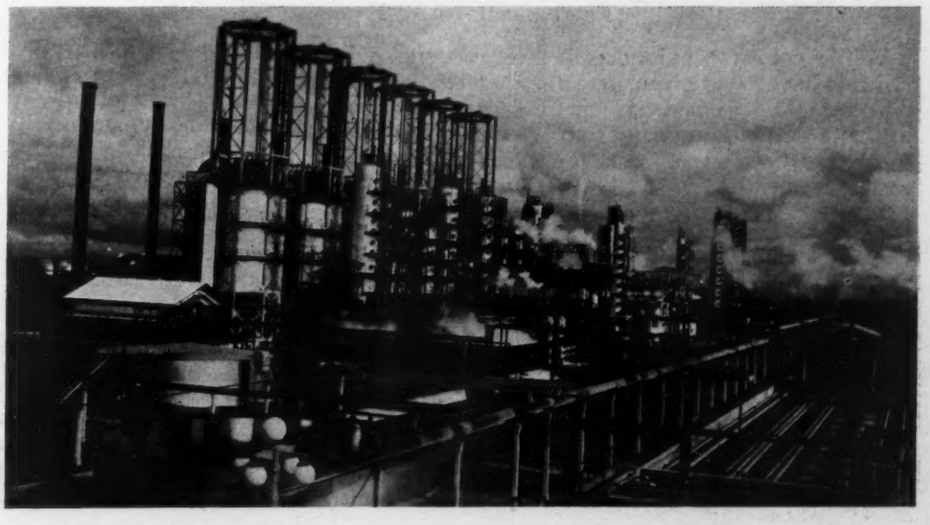
efficient which was reflected back in a loss in yield. These coils were removed and replaced with a 1000-square-foot tube bundle, as a reboiler in the base of the column through which a portion of the heat medium passes under controlled conditions.

Approximately 670 barrels per hour of heat medium is passed through the shell sides of the two heat medium exchangers and about 50 barrels per hour through the reboiler bundle. The tower bottom temperature is held at 385° F., and 5200 pounds per hour of low-pressure exhaust steam is introduced into the tower through a spider located below the reboiler bundle.

The time the unit can be kept on stream is determined by the rate of fouling of the heat-medium exchangers. Factors which influence the fouling rate have been found to be the amount of extraneous gas oil and caustic included in the feed and the steam added ahead of the heat-medium exchangers. The function of the extraneous gas oil is to furnish some liquid phase in the final heat-medium exchanger and also to reduce the time that the very small amount of net bottoms is retained in the tower.

The condensed rerun pressure distillate is cooled and accumulated in a tank from which it is pumped to storage. Part of this condensate is returned to the top of the column for end-point control. Acidity of the vapor stream is neutralized with 13 pounds per day of ammonia which is fed into the vapor stream at the inlet of the vapor-to-charge exchanger.

With the operating conditions as outlined, runs of 3000 hours or more are consistently obtained without reduction of feed rate. Mercaptan regeneration in the unit is low, averaging only .005 percent mercaptan sulphur increase between the feed and the overhead distillate. Loss of gasoline fractions in the bottoms is practically nil, as a gap of 35° to 40° F. is consistently obtained between the end point of the overhead and the initial of the bottoms. Additional evidence of the excellent separation obtained is afforded by the fact that plant yields are equal to yields obtained by laboratory distillation.



Turbine driven centrifugal pumps on the heat medium circuit are shown at the top.

At the right is a view of the Watson plant from rerun unit.

Pyrolysis *of Several Lower Hydrocarbons* In the Presence of Methyl-Chloride

A Study of CH_4, C_2H_6, C_2H_8 and C_2H_4

H. C. LU*, and R. L. HUNTINGTON,
University of Oklahoma, Norman, Oklahoma

PYROLYSIS of the lower hydrocarbons in the presence of methyl-chloride can be explained by the existence of free radicals. The removal of hydrogen in the form of hydrogen chloride succeeds to a certain extent in obtaining unsaturated hydrocarbons, but in order to make this process industrially feasible, further experimentation is necessary.

The present paper reports experiments with propane, ethane, and ethylene in presence of methyl-chloride or natural gas, calcium phosphate being used as a catalyst.

SINCE large quantities of methane are available in different parts of the world both in natural and manufactured gases, it is not surprising that much study has been done on its thermal decomposition to form either carbon and hydrogen or higher hydrocarbons and liquid fuels. As a result, much light has been thrown on the mechanism of, as well as the industrial application of, the thermal decomposition of methane.

The decomposition of methane begins in the absence of a catalyst at temperatures between 525 - 800° C.,[1] but the decomposition becomes considerable only at much higher temperatures. The decomposition products, besides carbon and hydrogen, may consist of some higher hydrocarbons, including ethane, olefins, diolefins, acetylene and aromatic compounds.

Theory of Methane Decomposition. The mechanism of methane decomposition has been a subject of much debate in recent years. Bone and Coward[2] introduced the concept of free radicals such as $CH_3\cdot$, $CH_2{:}$, and $CH{:}$ as the primary products of decomposition. These "residues," which can only exist for a very short period, may subsequently form $CH_2{=}CH_2$, $CH{\equiv}CH$, break down to carbon and hydrogen, or be hydrogenated into methane again. Stanley and Nash[3] believe that the pyrolysis of methane occurs through a series of reactions of free radicals in the following manner:

$$2\ CH_4$$
$$\downarrow$$
$$CH_3{-}CH_3 \rightleftharpoons 2\ CH_3\cdot + H_2$$
$$\downarrow$$
$$CH_2{=}CH_2 \rightleftharpoons 2\ CH_2{:} + H_2$$
$$\downarrow$$
$$CH{\equiv}CH \rightleftharpoons 2\ CH{:} + H_2$$
$$\downarrow$$
$$2\ C + H_2$$

Also $n\ (CH{:}) \rightarrow Cn\ Hn$

and $n\ (CH{:}) \rightarrow Cn\ H(n{-}m) + 0.5m\ H_2$

While concrete evidence of the existence of free radicals have been given by Paneth et al[4] the question whether the primary product of decomposition of methane is methylene or a methyl radical is still open to dispute. Several authors[5,6] believe that the following reactions:

(1) $CH_2{:} + H_2 \rightarrow CH_3\cdot + H$
(2) $CH_2{:} + CH_4 \rightarrow 2\ CH_3$
(3) $CH_3\cdot + H_2 \rightarrow CH_4 + H$
(4) $2\ CH_3 + H_2 \rightarrow 2\ CH_4$

take place as they require less energy of activation. They will be produced with greater speed than the following reactions:

(5) $CH_2{:} + CH_2{:} \rightarrow CH_2{=}CH_2$
(6) $CH_3\cdot + CH_3\cdot \rightarrow C_2H_6$

Reactions[5,6] which involve three-body collisions (the third body being non-specific in character), and require higher energies of activation, would probably occur to a much less extent than reactions (1), (2), (3), (4).

Thermal Stability of Methane. There are several difficulties in converting methane into higher hydrocarbons by pyrolysis. (1) Methane is quite thermally stable and is only partially decomposed in a short time at a temperature range of 900°-1200° C., while both its primary and secondary products decompose rapidly at that temperature with the production of hydrogen and coke. (2) Its primary products, the free radicals, react readily with hydrogen and then are converted back to methane again. But the reactions between free radicals themselves to form higher hydrocarbons only occur to a much smaller extent, probably due to the fact that these reactions involve three body collisions and need a greater energy of activation. These facts seem to explain the excessive formation of hydrogen and coke in the pyrolysis of methane, and the extremely low yield of higher hydrocarbons during the process.

Purpose of Experimental Work. It is the purpose of this experiment to see if methyl-chloride, which can readily be obtained by chlorination of methane, could be successfully converted into higher hydrocarbons by pyrolysis. Methyl-chloride, being decomposed to a considerable extent at a temperature range of 500°-900° C,[7] is more susceptible to thermal treatment than methane itself. The products of its decomposition would on that account be subject to less deterioration. In the decomposition of methyl-chloride, the greater part of the hydrogen is tied up in the form of hydrogen chloride. It is therefore hoped that the reaction between the free radicals to form higher hydrocarbons may proceed to a greater extent.

Laboratory Apparatus. The apparatus is shown in Figure 1. Methyl-chloride is generated in G by heating a mxture of methyl alcohol, concentrated sulphuric acid and common salt with a yield of about 50-55 percent of the theoretical amount. The gaseous methyl-chloride thus obtained contains a certain amount of hydrogen chloride which is removed in a water scrubber, S. The

* Home address — Chungking, China.

outgoing gas then contains 95-98 percent CH_3Cl as estimated by absorption with glacial acetic acid,[8] and is stored in the gas holder W, saturated salt solution being used as a confining liquid to avoid excessive solution of methyl-chloride. From the gas holder W, the gas is led through a drier E, filled with silica jel, and a flowmeter A, to the cracking tube Q. In case methyl-chloride is to be mixed with another gas before cracking, the latter is stored in the gas holder P, from which it passes through the flowmeter D, and is mixed with methyl-chloride in O before entering the cracking tube. If necessary the gases may be directly mixed in a gas holder and passed through one of the flowmeters to the cracking zone. The cracking tube consists of a quartz tube Q, ¼-inch internal diameter and 26 inches long, of which about 10 inches forms the heating zone. The temperature is measured by a chromel-alumel thermocouple, T. The decomposition products which come out of Q pass successively through a tar-catcher C, a condenser, and the receiver R, where light oil is condensed and collected. Hydrogen chloride in the gaseous mixture is scrubbed with water in scrubber B. The volume of remaining gases is measured at atmospheric pressure in the holder H, from which samples are taken and analyzed. The undecomposed methyl-chloride is determined and removed by shaking the mixture with fresh portions of water. (One c.c. of water dissolves approximately 4 c.c. of methyl-chloride under normal conditions.) The amount of unsaturated hydrocarbons is determined by absorption in saturated bromine water and the higher olefins (C_3 and higher) are determined by absorption in 87 percent by weight of (H_2SO_4) sulphuric acid solution.

Experimental Results

Non-catalytic treatment of methyl-chloride. Methyl-chloride was decomposed in an empty quartz tube at 600°-900° C. The conditions and results of the pyrolysis are shown in Table One.

After the removal of hydrogen chloride, unsaturated hydrocarbons and undecomposed methyl-chloride, the remaining gases are mainly hydrogen and methane. The wall of the quartz tube, after a 3-hour run, was coated with a thin layer of coke. No appreciable amount of tar and light oil was formed under these conditions.

Catalytic decomposition of methyl-chlorde. Table 2 shows the results of several kinds of catalysts employed in the pyrolysis.

Most catalysts used in the experiment have no material effect on the decomposition of methyl-chloride, except in the case of $PdCl_2$, in the presence of which methyl-chloride begins to decompose in the neighborhood of 270° C. instead of the ordinary decomposition temperature around 500° C. A small quantity of solid compound with a naphthalene odor was also found in all experiments. In every case methyl-chloride when it is pyrolyzed, yields mainly of carbon and hydrogen and methane, besides small amounts of unsaturated hydrocarbons. It is of interest, therefore, to see whether or not better results could be obtained when methyl-

TABLE 1

Temp. °C.	Gas Rate Liters/ Hour	Approx. Contact Time— Seconds	Analysis of Cracked Gas: Total Unsaturated Hydrocarbons Volume Percent	Analysis of Cracked Gas: Undecomposed Methyl-chloride Volume Percent
600	8	3	4.2	72.0
700	8	3	5.0	45.5
800	8	3	6.5	38.2
900	8	3	4.0	14.0

TABLE 2

Catalyst	Temp. °C.	Gas Rate Liters/ Hour	Analysis of Cracked Gas: Total Unsaturated Hydrocarbons Percent	Analysis of Cracked Gas: Undecomposed Methyl-chloride Percent
$CaCl_2$ deposited on silica jel	650	3.7	4.2	58.0
Al_2O_3	800	3.7	2.2	.....
$Ca_3(PO_4)_2$*	700	3.7	2.0	.....
$Ca_3(PO_4)_2$*	800	3.7	5.4	.....
$Ca_3(PO_4)_2$*	900	3.7	0.5-1	18.0
$PdCl_2$ deposited on asbestos fibre	300–500	3.7	nil	(calc.)50.0

TABLE 3

	CH_3Cl	Natural Gas
Temperature °C	610	610
Gas Rate Liters/Hour	3.8	3.9
Duration of Run	60 min.	60 min.
Gasoline evaporated-gm	20.6	21.0
Total weight of tar and light oil-gm	11.10	10.60
Cracked gas—Liters	6.9	7.5
Analysis of Cracked Gas:		
Total unsaturated hydrocarbons	22.0%	14.5%
Undecomposed methyl-chloride	51.0%	....

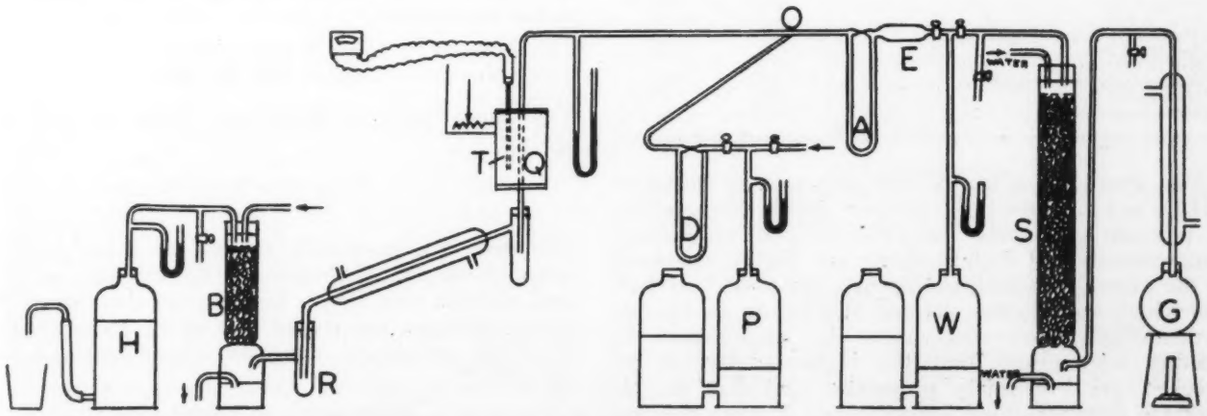


FIGURE 1
Experimental Apparatus
G-Methyl-Chloride Generator. B and S, Water Scrubber for HCl. H, P and W, Gas Holders. E, Drier, filled with Silica Gel. A, Flow Meter. Q, Cracking Tube. O, Gas Mixing Tube. T, Thermocouple. C, Tar Catcher. R, Receiver.

chloride is mixed with hydrocarbons, particularly of C_2 and higher homologues.

Pyrolysis of Methyl-chloride with Gasoline Vapor. Methyl-chloride was bubbled through about 80 c.c. of regular gasoline motor fuel contained in a tube immersed in a water bath with the temperature so adjusted as to maintain as uniform a rate of evaporation as possible. The mixture of methyl-chloride and gasoline vapor was then led to the cracking tube which was filled with $Ca_3(PO_4)_2$, care being taken to keep the gasoline vapor from condensation. A check run was made under substantially similar conditions by using natural gas (97 percent CH_4, 1.9 percent C_2H_6 and 1 percent C_3H_8) in place of methyl-chloride as the carrying gas. The results are shown in Table 3.

Although there is no material difference between the yields of liquid products, it is interesting to observe the noticeable increase of unsaturated hydrocarbons in the cracked gas from the CH_3Cl gasoline mixture.

Pyrolysis of Propane-CH_3Cl and Ethane-CH_3Cl mixtures. Propane (98 percent C_3H_8) was mixed with an equal volume of methyl-chloride and the mixture was led through the cracking tube at a constant rate. The cracking tube was filled with $Ca_3(PO_4)_2$. A check run was made by using a 50-50 mixture of natural gas and propane. Finally propane alone was cracked under similar conditions. The results are shown in Table 4.

TABLE 4

	Propane-CH_3Cl	Propane-Nat. Gas	Propane
Temperature °C	820	820	820
Duration of Run	60 min.	60 min.	60 min.
Gas Rate Liters/Hour	9.8	9.8	9.5
Tar and Light Oil-gm	0.5	0.5	0.65
Cracked Gas—Liters	11.5	12.2	14.2
Analysis of Cracked Gas:			
Total unsaturated hydrocarbons	26.0%	20.5%	33.5%
Higher olefins	8.0%	4.5%	8.5%
Undecomposed CH_3Cl	15.0%	....	....

Similar experiments have been made with 50-50 mixtures of methyl-chloride and a gas containing 60 percent C_2H_6, 32 percent C_3H_8 and 8 percent CH_4; the results are shown in Table 5.

TABLE 5

	Ethane CH_3Cl	Ethane Natural Gas
Temperature °C	880	880
Duration of Run	60 min.	60 min.
Gas Rate Liters/Hour	6.5	7.0
Cracked Gas-Liters	9.0	11.0
Analysis of Cracked Gas:		
Total unsaturated hydrocarbons	23.5%	19.5%
Higher olefins	1.5%	1.0%
Undecomposed CH_3Cl	11.0%	....

The above experiments with mixtures of propane-CH_3Cl and ethane-CH_3Cl indicate that in the cracking of propane and ethane the yields of total unsaturated hydrocarbons and higher olefins are slightly increased in the presence of methyl-chloride. The actual mechanism which leads to the increase of yield of unsaturated hydrocarbons, however, cannot be ascertained. By making assumptions that the higher olefins in the cracked gas are solely propylene, and that all the increase in unsaturated hydrocarbons is from the conversion of methyl-chloride, the yields of unsaturated hydrocarbons on the basis of decomposed methyl-chloride are approximately 20 percent in both cases.

Pyrolysis of Ethylene-CH_3Cl Mixture. Table 6 shows the results of experiments on a 50-50 C_2H_4-CH_3Cl mixture and the check runs.

TABLE 6

	Ethylene-CH_3Cl	Ethylene-Nat. Gas
Temperature °C	820	820
Duration of Run	60 min.	60 min.
Gas Rate Liters/Hour	8.4	9.0
Tar and Light Oil-gm	0.40	0.45
Cracked Gas-Liters	9.3	11.8
Analysis of Cracked Gas:		
Total unsaturated hydrocarbons	22.0%	19.2%
Higher olefins	0.5%	0.5%
Undecomposed CH_3Cl	12.0%	....

Discussion of Results

The poor yield of unsaturated hydrocarbons and the formation of carbon, hydrogen and methane from the pyrolysis of methyl-chloride suggest that the primary step of decomposition of methyl-chloride perhaps takes the form of:

$$CH_3Cl \rightleftharpoons CH_2: + HCl$$

The greater part of the methylene radicals formed under the conditions of pyrolysis is instantly broken up into carbon and hydrogen, and the latter might react with other methylene radicals to form methane, as illustrated by the following series of reactions:

$$CH_2: \rightleftharpoons C + H_2$$
$$CH_2: + H_2 \rightleftharpoons CH_3\cdot + H$$
$$CH_3\cdot + H_2 \rightleftharpoons CH_4 + H$$

The assumption that reactions like:

$$CH_2: + CH_2: \rightarrow CH_2 = CH_2$$
$$CH_3\cdot + CH_3\cdot \rightarrow C_2H_6$$

only occur to a very small extent, helps to explain the low yield of unsaturated hydrocarbons during pyrolysis. It also further strengthens the theory suggested by some authors that these reactions only occur in three-body collisions and require a higher energy of activaton. In the pyrolysis of mixtures of methyl-chloride with ethane or propane, it is possible to assume the first step of the reaction as dehydrogenation of ethane and propane into corresponding olefins:

$$C_2H_6 \rightleftharpoons C_2H_4 + H_2$$
$$C_3H_8 \rightleftharpoons C_3H_6 + H_2$$

These olefins then react with methylene radicals from decomposition of methyl-chloride in the manner suggested by Lenher[9,10]:

$$C_2H_4 + CH_2: \rightleftharpoons C_3H_6$$
$$C_3H_6 + CH: \rightleftharpoons C_4H_8$$

The above products then may break up into lower olefins:

$$2C_3H_6 \rightleftharpoons C_2H_4 + C_4H_8$$
$$C_4H_8 \rightleftharpoons 2C_2H_4$$

However, the possibility cannot be ignored that the presence of methyl-chloride in the cracking of ethane and propane may simply help the decomposition of the latter, and give rise to the type of reactions similar to "induced pyrolysis" suggested by Hessels and coworkers.[11]

Summary and Conclusion

Pyrolysis of methyl-chloride was studied under noncatalytic conditions and also in the presence of several types of catalysts. The products of decomposition, besides a small amount of unsaturated hydrocarbons,

consist of carbon, hydrogen, hydrogen chloride and methane.

Comparison has been made between the cracking of mixtures of methyl-chloride with ethane, propane, and ethylene, and similar mixtures of natural gas in the place of methyl-chloride. In these experiments a greater yield of unsaturated hydrocarbons in the cracking of CH_3Cl mixtures was noticed. By examining the results of the experiments several possible types of reactions have been suggested for the thermal decomposition of methyl-chloride.

The low yield of olefins, and the rapid decomposition of methyl-chloride into carbon and hydrogen during its pyrolysis, make the process unattractive at least at the present for the purpose of obtaining unsaturated hydrocarbons from methyl-chloride.

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Rapid Method for the Determination of Mercaptan Sulphur in Refinery Caustic Soda Scrubbing Solutions

DURING the past decade dilute aqueous caustic soda solutions have been extensively used for the removal of hydrogen sulphide and mercaptans from petroleum distillates and gases. Where mercaptans are the chief components extracted the scrubbing solutions are regenerated and used again; this cycle is continued until a build-up of sodium sulphide from the neutralization of hydrogen sulphide renders the solution worthless for extraction of mercaptans. The mercaptan stripping of the spent solution is accomplished by countercurrently blowing with steam or sulphur-free hot air or gases in a bubble plate tower.

It is sometimes necessary to know the mercaptan content of the scrubbing solution. This determination can easily be accomplished by some adaption of the method of Willard and Fenwick[1], which is essentially as follows: A small amount of caustic soda is buffered slightly on the alkaline side; the sulphide and mercaptan are titrated with silver nitrate using a silver-mercury half cell and a potentiometer to record the changes in E.M.F. The main disadvantage of this method is that it requires a sensitive potentiometer which is not always available.

A rapid method utilizing the reagents and apparatus found in a small laboratory has been developed. This method can also be used on refinery or natural gases for the determination of mercaptans, by passing a known volume of the gases through a caustic-soda solution and then proceeding in the usual manner. The method outlined here is essentially the reverse of the scrubbing operation in the plant. The mercaptans are forced into the hydrocarbon phase where they are determined by one of the two commonly accepted methods[2,3] for mercaptans in gasoline.

Spent caustic-soda solutions were analyzed by an adaption of the method of Willard and Fenwick[1] and by the method in question. The comparison of the results of the two methods is not in close agreement, but is accurate enough for ordinary control work. However, if the reagents are chilled, much better agreement is obtained. This comparison of the results on refinery spent caustic by the use of the potentiometric method and by the use of the method in question using no special precautions is given in Table 1.

Procedure

Place 5 cc. of spent caustic-soda solution in a 500 cc. separatory funnel. Add 100 cc. mercaptan-free (200-300° F.) naphtha. Add 100 cc. of distilled water and agitate. Add slowly 5 cc. concentrated hydrochloric acid and agitate for 3 minutes. Discard aqueous layer; add 100 cc. of acidified 10 percent cadmium-chloride solution and agitate. Discard aqueous layer. Wash with 100 cc. of distilled water and discard washings. Filter naphtha and titrate according to one of the two methods noted.[2,3]

The one used by the writer is an adaption of the method of Borgstrom and Reid[2] which is given below. Add a known excess of .05N $AgNO_3$ to the filtered naphtha solution which is contained in a 500 cc. Erlenmeyer G. S. flask and agitate for 5 minutes. Add 2 cc. of iron alum (20 percent solution of ferric ammonium sulfate acidified with nitric acid) solution. Back nitrate with .05N NH_4CNS until a pink color remains after 3 minutes shaking.

Calculation:

$$666 \frac{(\text{cc. N/20 } AgNO_3 - \text{cc. N/20 } NH_4CNS) \times .0016 \times 100}{5 \times \text{Density of Caustic solution}} = \text{percent mercaptan sulphur.}$$

A rapid control method for the determination of mercaptan sulphur in refinery caustic soda solutions was developed. A comparison of the results obtained by the use of this method and by a potentiometric method was made.

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TABLE 1
Percent of Mercaptan Sulphur

Sample	Method	Potentiometric Method
1.	0.51	0.47
2.	.28	.30
3.	.43	.49
4.	.71	.60
5.	.57	.50
6.	.28	.24
7.	.35	.38
8.	.12	.13

Portable Unit Measures Gas For Gasoline Content

SALE of gas at the separator, in those fields where the liquid hydrocarbon content makes gasoline-extraction plants profitable, is an item in lease management which is closely checked by producer and gasoline-plant operator alike.

In the Oklahoma City field, Phillips Petroleum Company has developed a compact and highly accurate test unit which it mounts in the rear of coupe model test car, and which is taken direct to the well site and tied in to the gas line at the separator, obtaining and recording the gasoline content at that point. These determinations are required by plant operators every three months on wells tied in to their collecting mains.

The plant as developed is said to be as accurate as a charcoal test and considerably faster. At the gas flow line connection is made with the test unit through a short extension with usual control valve. The gas is taken from a side nipple at the top of a short vertical section, into which the gas enters near the mid section, with space at the bottom for the accumulation of such liquid as may be extracted by initial expansion of the gas as it leaves the flow line.

From the drip the flow is through a short length of hose to the inlet of the test unit, which, insofar as equipment and stages are concerned, is a miniature natural gasoline plant, operating on the compression system.

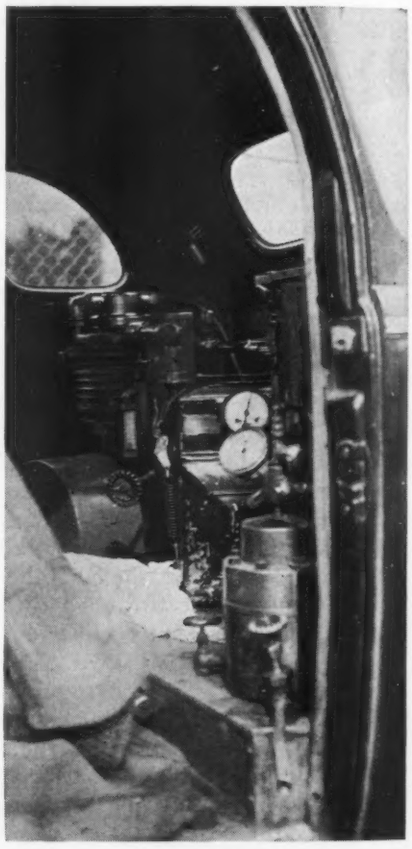
Mounted in the coupe back of the driver's seat are a gas scrubber, a two-stage compressor (consisting of a vacuum pump and a high-stage cylinder) gas meter, pressure gauges, mercury manometer, filter and condenser.

After a metered quantity of gas has been processed through the plant and the gasoline extracted and collected in a graduate, the liquid is heated by means of car engine temperature to the standard 60° F. and the volume in cubic centimeters at that temperature read off.

Complete determinations for a thousand feet of gas are not required, the degree of accuracy obtained being so high that smaller quantities may be extracted and their readings multiplied by the proper constant to convert the readings into quantity recovered per standard volume of gas.

Under the turtle deck of the car are carried the necessary supplies and fittings for conducting a series of tests while the car is on the road and in addition standard laboratory equipment for determining the amount of air entrained in the gas.

Use of a mobile testing unit such as the one described permits actual field tests of gasoline content to be made at the well, without possible loss through evaporation or change from initial conditions, avoids the collection of samples and the possibility of wide variations through errors entering the working with small quantities of gas and fluids, and enables a field check of any well to be made without interfering with production in case the flow line has already been equipped for this method of testing.



Compact miniature natural gasoline plant nested within the rear body space of the test coupe includes gas meter, two-stage compressor for vacuum and pressure determinations, scrubber filter, condenser and all necessary gauges and manometers for field gasoline determinations in samples from well flow line.

Valve, vertical drip and short section of high-pressure hose tie the portable test plant directly to the gas flow line and permit accurate determinations to be made of hydrocarbon content as the gas enters the collecting system of buyer.

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Peak of War's Damage to Oil Export Business Passed

THE war's effect on export business of the American oil industry probably has reached and passed its maximum severity, and any change hereafter should be for the better and not for the worse.

Latest statistics, covering June and the first half of 1941, were on their face unfavorable, having compared with figures on exports before the loss of the European markets through the German domination of the continent after the invasion of the Low Countries and France.

However, beginning with figures for July, 1941, the statistics on American oil exports will be more favorable in comparison with those of last year.

Moreover, domestic consumption in the United States has steadily expanded while the war was bringing uninterrupted declines in export business, and the gains in domestic use have more than compensated for losses of foreign trade. Consequently, lost overseas business is hardly missed now, for the industry as a whole, and what export trade is left is of relatively less importance.

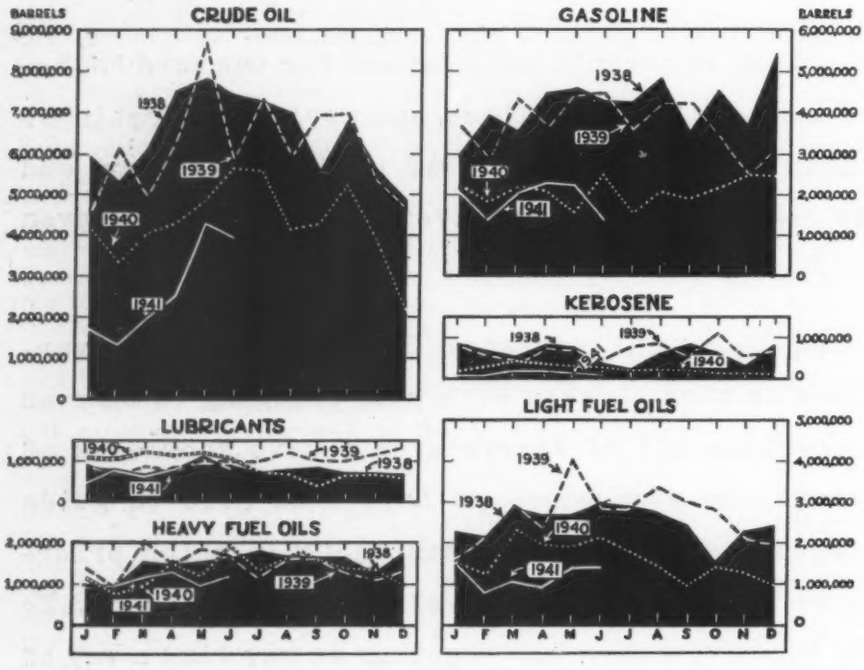
Even further curtailment of exports, therefore, would not be particularly alarming, considering the low level to which the trade already has sunk.

Actually, however, exports lately have been holding fairly steady, and they have compared favorably with those a year ago; and while smaller exports to Japan, a leading customer, are in prospect, because of the government's ban against shipments to that country, there are to be henceforth increased shipments to Great Britain and Russia, with the British taking relatively large quantities from the Gulf Coast under the lease-lend program.

In the first six months of 1941, total exports were 34.1 percent smaller than in the corresponding months of 1940, with shipments of crude down 40.2 percent and the movement of refined products off 30.3 percent, although shipments of aviation gasoline and residual fuel oil were down only about 10 percent. Figures for June showed no improvement over those for the first half of the year as a whole.

However, for July, August, and September, forecasts of export demand by the Bureau of Mines have been progressively more favorable. The bureau's estimates of crude oil exports were as follows:

First Half Exports One Third Lower Than Last Year



ITEM	JUNE 1940	JUNE 1941	JUNE Percent Change	FIRST 6 MONTHS 1940	FIRST 6 MONTHS 1941	FIRST 6 MONTHS Percent Change
Crude Oil	5,692,000	3,934,000	— 30.9	26,415,000	15,793,000	— 40.2
Products:						
*Motor Fuel	2,581,000	1,262,000†	— 51.1	13,090,000	9,421,000	— 28.0
Aviation Gasoline	646,000	386,000‡	— 40.2	2,336,000	2,114,000	— 9.5
*Kerosene	332,000	112,000	— 66.3	2,291,000	805,000	— 64.9
*Gas Oil and Distillate	2,129,000	1,380,000	— 35.2	11,326,000	6,830,000	— 39.7
Residual Fuel Oil	1,959,000	1,267,000	— 35.3	7,710,000	6,829,000	— 11.4
Lubricants	1,075,000	831,000	— 22.7	6,759,000	4,705,000	— 30.4
Wax (thousands of pounds)	13,195	16,058	+ 21.7	129,806	80,698	— 37.8
Coke (short tons)	30,700	31,400	+ 2.3	117,000	120,700	+ 3.2
Asphalt (short tons)	35,200	18,800	— 46.6	157,700	122,300	— 22.4
Miscellaneous Oils	45,000	48,000	+ 6.7	624,000	305,000	— 51.1
§Total Refined Products	8,516,000	5,217,000	— 38.7	43,716,000	30,458,000	— 30.3
Total Crude and Products	14,208,000	9,151,000	— 35.6	70,131,000	46,251,000	— 34.1

*Exclusive of "shuttle" movement. † Includes 5,000 barrels benzol. ‡ Includes 54,000 barrels anti-knock compounds. § Not the sum of the above figures, some of which do not indicate barrels.

Crude Oil Exports

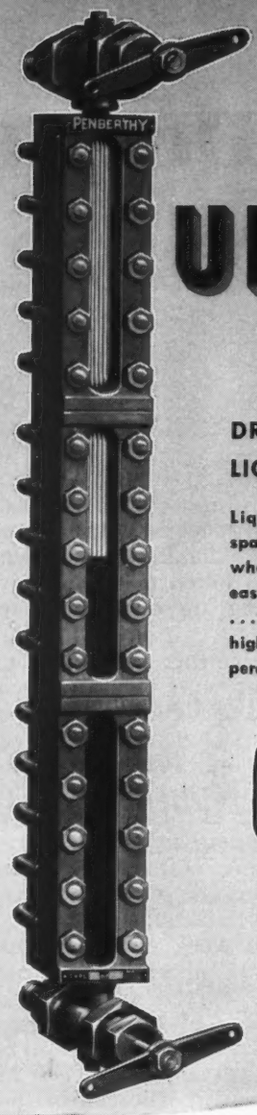
Month	1940 Actual (Barrels)	1941 Forecast (Barrels)
July	5,607,000	2,900,000
August	4,170,000	3,500,000
September	4,260,000	4,000,000

The bureau's forecasts of exports of gasoline, made with the aid of principal exporters, were as follows:

Gasoline Exports

Month	1940 Actual (Barrels)	1941 Forecast (Barrels)
July	1,687,000	2,000,000
August	2,087,000	2,200,000
September	1,907,000	2,700,000

QUALITY UNCOMPROMISED



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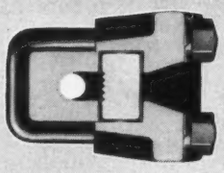

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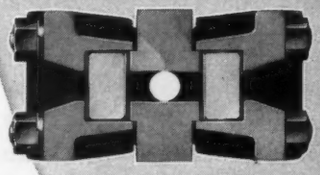
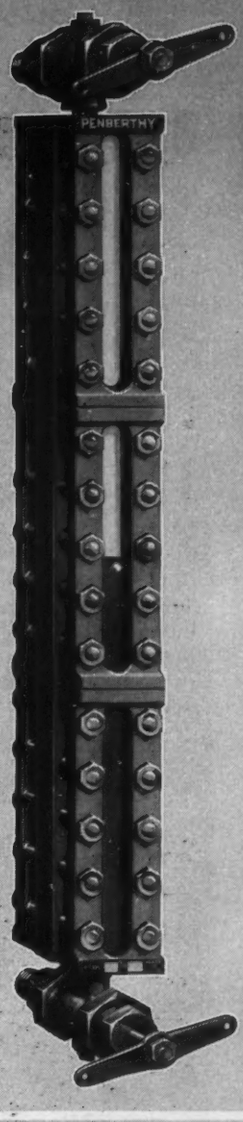
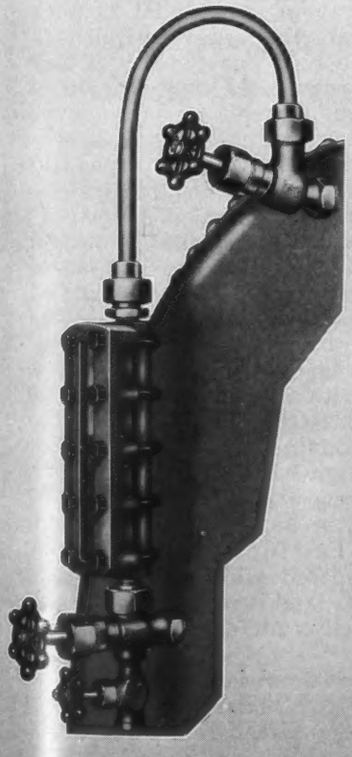
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . similar to Reflex types.





Penberthy Liquid Level Gages

ALL PENBERTHY GAGES CONFORM WITH A. P. I.—A. S. M. E. REQUIREMENTS



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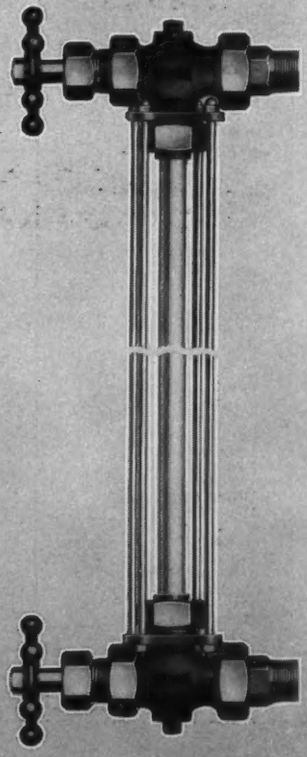

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PENBERTHY PRODUCTS

Oil Demand Runs High Despite Curtailment of Eastern Use

L. J. LOGAN

DESPITE the loss of a large part of its tanker tonnage, through diversions to British use, the oil industry of the United States managed to reach Labor Day without having failed to fulfill the prevailing record-breaking demand for petroleum products except in so far as it was ordered by the government to reduce deliveries to service stations in the East Coast district by 10 percent in August.

However, the maintenance of the movement of oils to East Coast consumers was achieved during August only at the expense of normal inventories, as the scarcity of shipping facilities prevented usual maintenance of stocks after the latter part of July.

Total Oil Demand 8.1 Percent Larger in June Than Year Previously; Domestic Use Up 13.9 Percent; Similar Gains for First 6 Months 6.3 and 10.6 Percent

(Figures indicate barrels, and are from Bureau of Mines)

ITEM	JUNE			FIRST 6 MONTHS		
	1940	1941	Percent Change	1940	1941	Percent Change
SUMMARY—						
Total Demand	120,624,000	130,447,000	+ 8.1	712,938,000	753,538,000	+ 5.7
Daily average	4,021,000	4,348,000	+ 8.1	3,917,000	4,163,000	+ 6.3
Exports:						
Crude petroleum	5,692,000	3,934,000	— 30.9	26,415,000	15,793,000	— 40.2
Refined products	8,516,000	5,217,000	— 38.7	43,716,000	30,458,000	— 30.3
Total exports	14,208,000	9,151,000	— 35.6	70,131,000	46,251,000	— 34.0
Domestic Demand:						
Total domestic demand	106,416,000	121,296,000	+ 13.9	642,807,000	707,287,000	+ 10.0
Daily average	3,547,000	4,043,000	+ 13.9	3,532,000	3,908,000	+ 10.6
TOTAL DEMAND FOR PRODUCTS						
Motor Fuel:						
Domestic	55,459,000	58,413,000	+ 5.3	278,622,000	308,834,000	+ 10.8
*Exports	2,581,000	1,262,000†	— 51.1	13,090,000	9,421,000	— 28.0
Total	58,040,000	59,675,000	+ 2.8	291,712,000	318,255,000	+ 9.1
Aviation Gasoline:						
Domestic	641,000	1,133,000	+ 76.7	3,032,000	4,185,000	+ 38.0
Exports	646,000	386,000‡	— 40.2	2,336,000	2,114,000	— 9.5
Total	1,287,000	1,519,000	+ 18.0	5,368,000	6,299,000	+ 17.3
Kerosene:						
Domestic	3,952,000	3,918,000	— 0.9	35,048,000	35,042,000	— 0.02
*Exports	332,000	112,000	— 66.3	2,291,000	805,000	— 64.9
Total	4,284,000	4,030,000	— 5.9	37,339,000	35,847,000	— 3.9
Gas Oil & Distillate Fuels:						
Domestic	7,028,000	10,842,000§	+ 54.3	84,887,000	92,626,000	+ 9.1
*Exports	2,129,000	1,380,000	— 35.2	11,326,000	6,830,000	— 39.7
Total	9,157,000	12,222,000	+ 33.5	96,213,000	99,456,000	+ 3.4
Residual Fuel Oils:						
Domestic	25,048,000	29,200,000*	+ 16.6	169,057,000	188,014,000	+ 11.2
Exports	1,959,000	1,267,000	— 35.3	7,710,000	6,829,000	— 11.4
Total	27,007,000	30,467,000	+ 12.8	176,767,000	194,843,000	+ 10.2
Lubricants:						
Domestic	2,146,000	3,171,000	+ 47.8	11,806,000	15,043,000	+ 27.4
Exports	1,075,000	831,000	— 22.7	6,759,000	4,705,000	— 30.4
Total	3,221,000	4,002,000	+ 24.2	18,565,000	19,748,000	+ 6.4
Wax (thousands of pounds):						
Domestic	21,687	46,522	+114.5	146,885	242,223	+ 64.9
Exports	13,195	16,058	+ 21.7	129,806	80,698	— 37.8
Total	34,882	62,580	+ 79.4	276,691	322,921	+ 16.7
Coke (short tons):						
Domestic	101,900	116,000	+ 13.8	669,400	750,300	+ 12.1
Exports	30,700	31,400	+ 2.3	117,000	120,700	+ 3.2
Total	132,600	147,400	+ 11.2	786,400	871,000	+ 10.8
Asphalt (short tons):						
Domestic	570,400	746,400	+ 30.8	1,885,400	2,395,700	+ 27.1
Exports	35,200	18,800	— 46.6	157,700	122,300	— 22.4
Total	605,600	765,200	+ 26.4	2,043,100	2,518,000	+ 23.2
Road Oil:						
Domestic demand	1,275,000	1,356,000	+ 6.3	2,387,000	2,573,000	+ 7.8
Miscellaneous:						
Domestic	207,000	299,000	+ 44.4	900,000	1,696,000	+ 88.4
Exports	45,000	48,000	+ 6.7	624,000	305,000	— 51.1
Total	252,000	347,000	+ 37.7	1,524,000	2,001,000	+ 31.3

* Exclusive of "shuttle" movement. † Includes 5,000 barrels benzol. ‡ Includes 54,000 barrels anti-knock compounds. § Includes 666,000 barrels Diesel bunker oil. *Includes 1,656,000 barrels bunker fuel oil.

Up to August 1, there was only a slight reflection of the tanker shortage, thanks to the various measures taken to compensate for the giving up of tankers to the British.

But since then, additional tanker diversions and seasonal requirements have accentuated the transportation shortage; and serious difficulty in supplying the East Coast is threatened at least for the remainder of this year and the first several months of next year, after which relief is in prospect through completion of scheduled pipe line and tanker construction.

In the week ended August 23, there was a net withdrawal of 2,010,000 barrels from the aggregate stocks of crude oil, gasoline, gas oil, and residual fuel oil on the East Coast, an average of 287,000 barrels daily; whereas in the corresponding week last year there was an increase of 416,000 barrels, or 60,000 daily. These figures indicated that for the August 23 week this year, the industry failed to maintain East Coast stocks as well as last year in the total amount of 2,426,000 barrels for the seven days, an average deficiency of 347,000 barrels daily in the replenishing of the Eastern inventories.

For the week ended August 30, figures on crude stocks are not yet available, but East Coast stocks of gasoline, gas oil, and residual fuel oil in the aggregate were increased 873,000 barrels, an average addition of 125,000 barrels daily, compared with an increase of 1,537,000 barrels, or 220,000 daily, in the corresponding week last year. For the August 30 week, therefore, there was a deficiency of 664,000 barrels, or 95,000 daily, in replenishing East Coast refined stocks, as compared with the experience last year, and it remains to be seen how well crude stocks were maintained.

Information is being withheld by the government on the tanker diversions already made or to be

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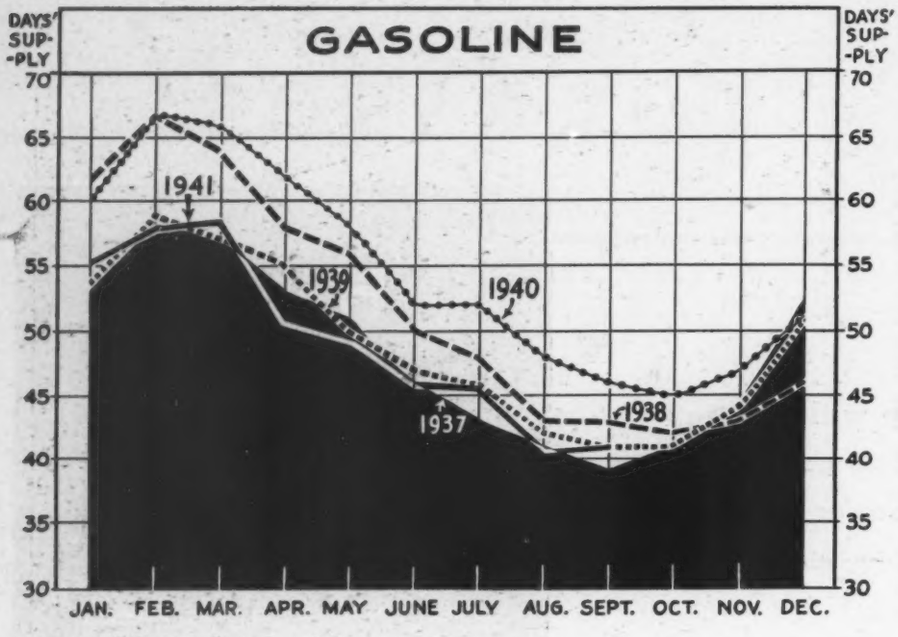
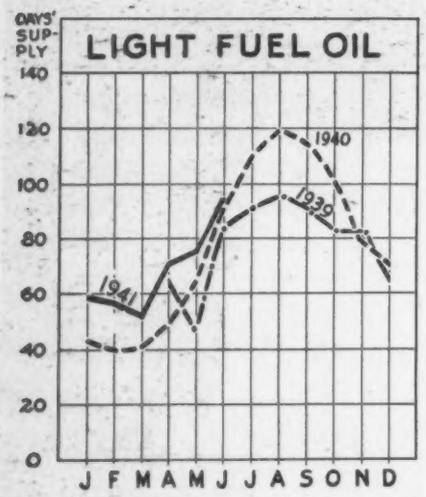
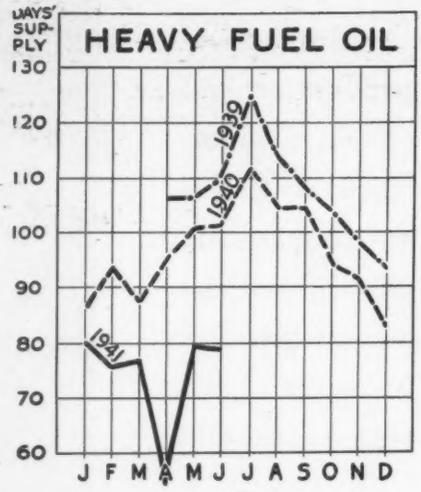
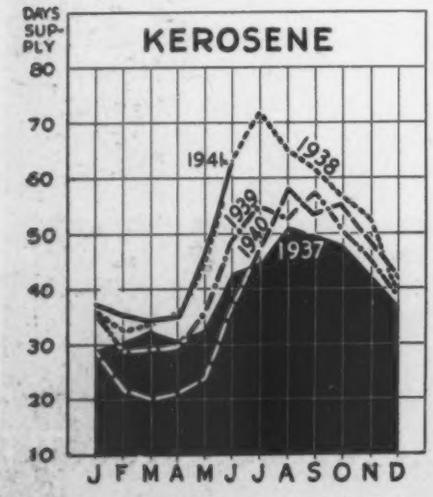
Days' Supply of Principal Refined Products in Storage

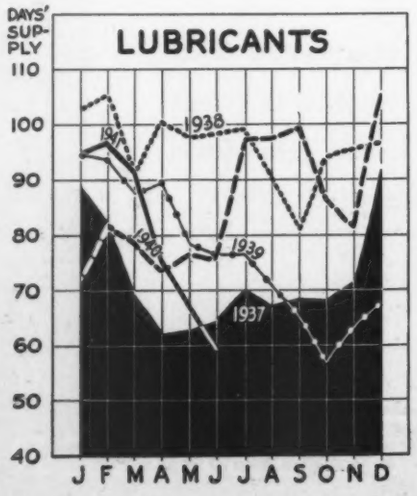
In relation to prevailing consumption, stocks of gasoline and light fuel oil are about same as in several other recent years; those of heavy fuel oil and lubricants are smaller than usual; and inventories of kerosene are above normal.











made in addition to the original 50-ship transfer, but it has been plausibly rumored that lately the East Coast has been deprived of the services of about 15 more American flag tankers that formerly plied coastwise and about 35 Norwegian tankers that brought in South American oils. If this is true, and if those boats are all that are to be transferred, it is to be expected that there will be a shortage of about 336,000 barrels daily (21.7 percent) in East Coast supplies during the fourth quarter of this year, equivalent to the carrying capacity of 84 average size tankers, and that the shortage for the first quarter of next year will be 276,000 barrels daily (17.7 percent), equivalent to 69 tankers. (These figures are based on calculations of the fact finding committee of the industry, revised to give consideration to measures taken to compensate for the loss of tonnage.)

The recent statistics on East Coast stocks makes the report of renewed diversions of around 50

Changes From Year Ago in Stocks of Crude and Refined Oils in the United States

(Figures Indicate Barrels)

LATEST WEEKLY DATA

(Sources: Crude stock, Bureau of Mines; all other figures American Petroleum Institute.)

STOCKS OF:	Aug. 31, 1940	Aug. 30, 1941	Percent Change
Gasoline	84,047,000	81,672,000	— 2·8
Gas Oil & Distillate	44,678,000	45,351,000	+ 1.5
Residual Fuel Oil	107,155,000	95,052,000	—11.3
Crude Oil	263,802,000*	248,910,000†	— 5.6

LATEST MONTHLY DATA

(Source: Bureau of Mines.)

	Stocks at End of June		
	1940	1941	Percent Change
SUMMARY—			
Crude Petroleum:			
Refinable in U. S.	261,971,000	259,075,000	— 1.1
Heavy in California	13,334,000	10,711,000	—19.7
Natural Gasoline	7,000,000	6,235,000	—10.9
Refined Products	283,905,000	276,477,000	— 2.6
Total, all Oils	566,210,000	552,498,000	— 2.4
Days' supply:			
June basis	141,000	127,000	— 9.9
6 Months' basis	145,000	133,000	— 8.3
PRODUCTS—			
Gasoline:			
Finished	86,276,000	82,495,000	— 4.4
Unfinished	7,293,000	7,347,000	+ 7.4
Total	93,569,000	89,842,000	— 3.9
Aviation Gasoline	5,268,000	7,341,000	+39.3
Kerosene	6,810,000	9,609,000	+41.1
Gas Oil & Distillate Fuels	26,412,000	30,620,000	+15.9
Residual Fuel Oils	85,448,000	75,938,000	—11.1
Lubricants	8,161,000	7,383,000	— 9.9
Wax (thousands of pounds)	110,346	110,481	+ 0.1
Coke (short tons)	697,000	382,000	—45.2
Asphalt (short tons)	681,000	841,000	+23.5
Road Oil	1,257,000	1,150,000	— 8.5
Miscellaneous	411,000	381,000	— 7.3
Other Unfinished Oils	41,340,000	41,825,000	+ 1.2

* Stocks, August 24, 1940.
† Stocks, August 23, 1941.

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ships appear quite credible, and it remains to be seen if there is any basis for intimations that these additional transfers may reach 100 ships besides the 50 originally diverted. If the added transfers should reach 100, the East Coast would be short 536,000 barrels daily (34.5 percent) in the fourth quarter, equivalent to 134 tankers, it is indicated, and 476,000 barrels (30.6 percent) in the first quarter of next year, representing the services of 119 tankers.

Tankers Uncertain

From statements given out from the office of the petroleum coordinator, no worth-while conclusion may be reached as to what actually is in store in the matter of supplying the East Coast, as Coordinator Ickes in the past has talked of the necessity for a 33 percent curtailment of consumption, while Deputy Coordinator Davies lately has expressed the "hope" that only a 10 percent curtailment of use would be necessary between now and spring, and none thereafter. Apparently, that optimistic hope could be realized, however, only through greatly increased use of railroad tank cars, utilization of Axis-owned tankers that are held in the Western Hemisphere, and material reductions of East Coast inventories, which heretofore have been considered as being only a little in excess of necessary working stocks.

Eastern Stocks

In supplying the East Coast without adequate transportation facilities, the industry has been concerned primarily with warding off shortages of gasoline and heating oil and so far has been remarkably successful. The East Coast stocks of gasoline on August 30 were within 1,515,000 barrels of those a year previously, with stocks at 20,261,000 barrels, while stocks of gas oil and distillate fuel were down 1,589,000 barrels from a year before at 15,266,000 barrels. In the meantime, however, it has not been possible to maintain stocks of residual fuel oil as well, and August 30 inventories of that product on the East Coast, having totaled 9,127,000 barrels, were 2,709,000 barrels smaller than a year previously. Apparently, some of the utility companies and other consumers of heavy fuel oils will find it necessary soon to switch from oil to coal for fuel. Stocks of the three principal products

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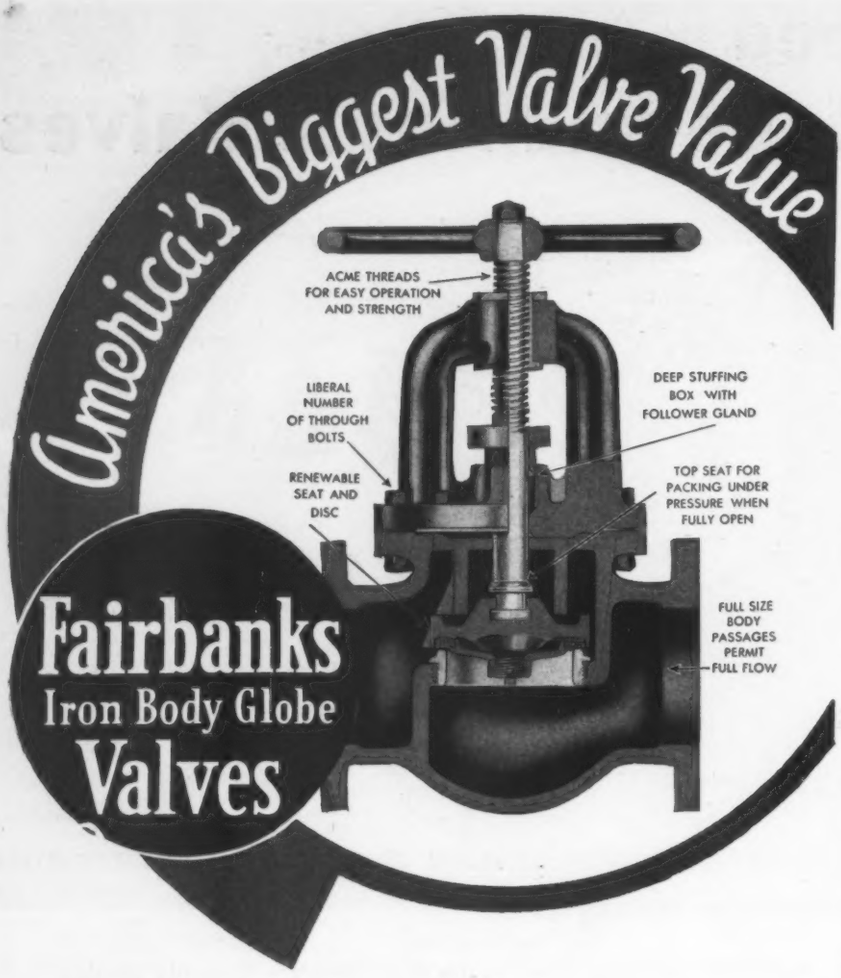
America's Biggest Valve Value
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LIBERAL NUMBER OF THROUGH BOLTS
RENEWABLE SEAT AND DISC
DEEP STUFFING BOX WITH FOLLOWER GLAND
TOP SEAT FOR PACKING UNDER PRESSURE WHEN FULLY OPEN
FULL SIZE BODY PASSAGES PERMIT FULL FLOW
Fairbanks
Iron Body Globe
Valves

Where else will your valve dollars buy such outstanding value as in this Fairbanks Iron Body Globe Valve?

Where else will you get valves made of a semi-steel of a tensile strength 66-2/3% greater than ordinary cast iron . . . that have a seat and disc which can be renewed in a few minutes right on the pipe line . . . with back seating on spindle to permit repacking under pressure . . . with strong deep-cut threads . . . with guides in body to insure perfect seating of discs . . . bushed throughout to insure long, dependable service?

Only when you try one of these Fairbanks Valves will you believe that any valve could operate so easily, close so tightly and cost so little for maintenance.

Get a "close-up" of the biggest valve value by asking your Fairbanks distributor to compare this valve, part for part, with any other.

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THE FAIRBANKS COMPANY

20 EAST 4TH ST., NEW YORK, N. Y.

Valves, Dart Unions, Hand Trucks and Wheelbarrows

Boston, Mass., Pittsburgh, Pa.
Distributors in Principal Cities
Factories: Binghamton, N. Y., Rome, Ga.

combined amounted to 44,654,000 barrels on August 30, or 5,813,000 less than a year before.

Unprecedented Demand

In spite of the trouble in supplying the East Coast, demand for petroleum so far has continued at unprecedented proportions. In its forecasts for September, the Bureau of Mines took into consideration the announced plans to curtail the distribution of gasoline in the East Coast district by 10 percent and calculated that the attainment of that objective in September would reduce estimated consumption in that area by about 2,000,000 barrels. But the bureau pointed out that the effect of the East Coast situation would be somewhat offset by increasing defense requirements and an anticipated increase in total exports.

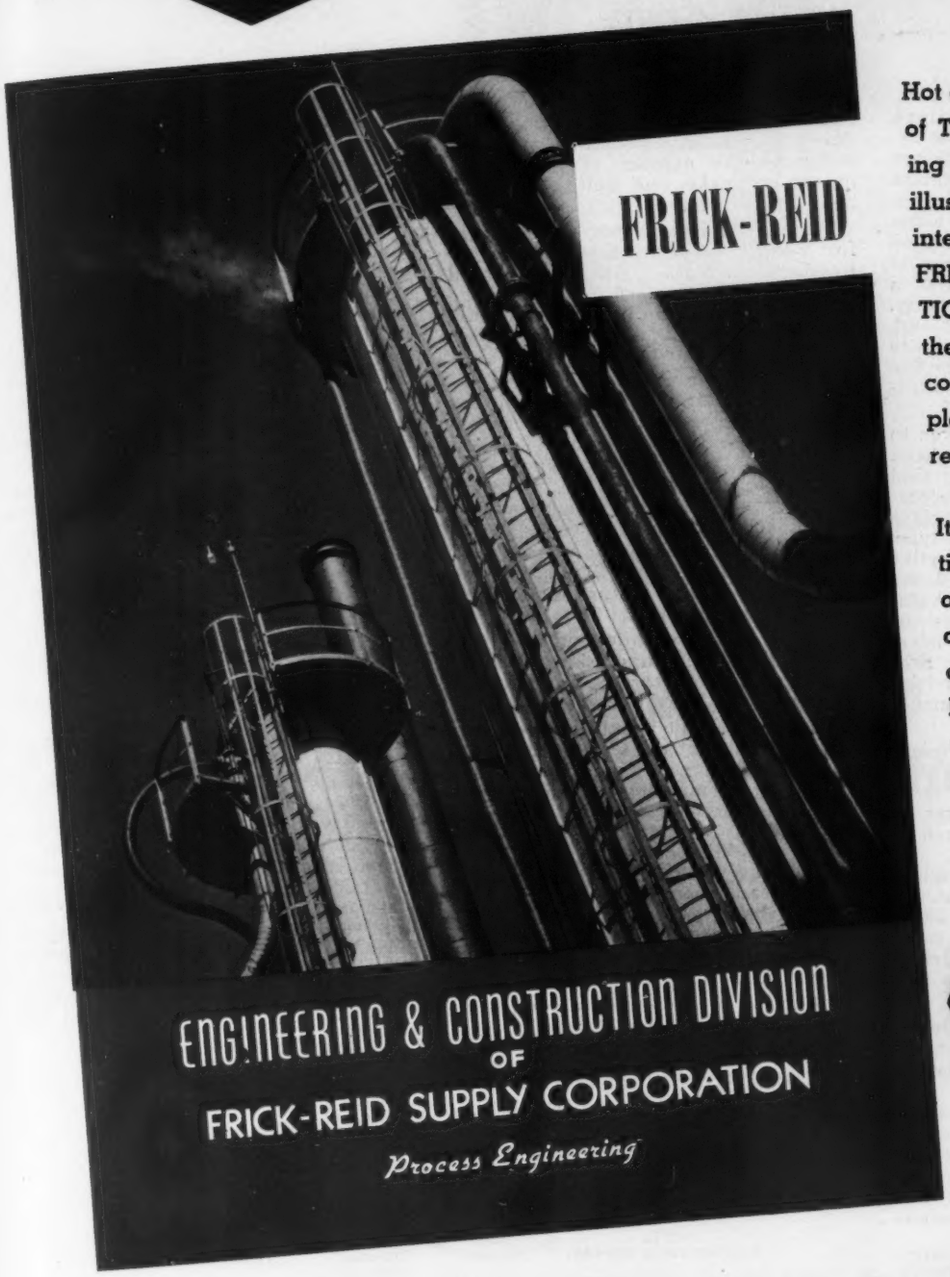
The agency estimated that the nation's domestic demand for motor fuel in September would amount to 57,500,000 barrels, an increase of 10 percent over the actual demand in September, 1940, and that exports would total 2,700,000 barrels, against 1,907,000 last September, indicating a gain of 11.1 percent in total demand. Fulfillment of this forecast would constitute a continuation of the trend heretofore this year in domestic consumption and further improvement in the trend of export business.

September Estimate

On the basis of the estimated demand for gasoline, the bureau calculated that the daily average requirements for domestic crude oil in September would be 3,960,000 barrels. That would be 20,000 barrels more than the estimated daily average demand for August and 7 percent more than the actual demand for September of last year.

In regard to the national situation, the bureau stated that the supply of all oils seemed to be ample. The seasonal level of total gasoline stocks is fairly normal, according to the agency, but the heavy liquidation of crude stocks might well be offset by some increases in the near future. During the second quarter of 1941, national stocks of refinable domestic crude oil decreased by 7,000,000 barrels. The principal changes by states of origin were decreases for Oklahoma, California, and Illinois, while stocks of Texas origin increased. Preliminary figures for July were said to indicate a further liquidation of 7,000,000 barrels.

LOOK FOR IT!



Hot off the press—the 1941 edition of The Refinery Catalog containing a 20-page section, profusely illustrated, which has to do with interesting achievements of the FRICK-REID SUPPLY CORPORATION in process engineering and the design and construction of complete refineries, gasoline plants, repressuring plants and recycling plants.

It points out that in polymerization, alkylation, isomerization and isoforming installations, along with the later types of cracking and reforming units, FRICK-REID makes available unusual process engineering experience, resources, management and organization.

Look for this FRICK-REID section in The REFINERY CATALOG—you'll find it interesting.

FRICK-REID SUPPLY CORPORATION

TULSA, OKLAHOMA

PROCESS ENGINEERING, DESIGN & CONSTRUCTION

Refineries - Gasoline Plants - Repressuring Plants - Recycling Plants

Causes and Preventions of Fires and Explosions in the Petroleum Industry[1]

G. M. KINTZ[2]

THE preceding experiments [REFINER, August, 1941, page 114] show that removing the fuel supply, the oxygen (air) supply, or the heat will extinguish the fire. Water is used ordinarily for extinguishing fires. Although water should not be used to fight most oil fires, it is very effective on some oil fires when employed in the form of a fine mist or fog and handled properly. The mist helps to exclude the air and, when in contact with the fire, turns to steam which further aids in excluding the air; also it tends to cool the burning substance.

The following information is given to point out the hazards of extinguishers, not to condemn any type that is sold and used in accordance with recommended practices, as there is a place for every extinguisher of approved type. No one type is likely to prove effective on all fires any more than one medicine is likely to cure all diseases. To evaluate the safety and effectiveness of various fire extinguishers, the Underwriters' Laboratories, Inc.,[7] divide fires into the following three classes and indicate the suitable type of extinguisher to use:

Class A fires are defined as incipient fires on which the quenching and cooling effect of quantities of water is of first importance, i.e., incipient fires in ordinary combustible materials, such as wood, paper, textiles, rubbish, etc.

Class B fires are defined as incipient fires on which the blanketing or smothering effect of the extinguishing agent is of first importance, i.e., fires in small quantities of rapidly burning material, such as gasoline, oils, or greases in vats or other open vessels or on floors.

Class C fires are defined as incipient fires in electrical equipment where the use of a non-conducting extinguishing medium is of great importance.

This classification is shown, opposite the following headings, in the form A-1, A-2, or A-1, B-1, etc., as the case may be. The letters A, B, or C designate the class or classes of fires on which the device is suitable. The figures following designate the number of devices required to make one unit of first-aid hand fire protection.

Experience has shown that charges for various types of first-aid fire extinguishers should be those furnished by the manufacturer of the device who cannot be expected otherwise to be responsible for unsatisfactory condition or operation.

Prospective users should first ascertain from authorities having jurisdiction under what conditions the various extinguishers will be accepted and should make contracts subject to appproval by them of setting, distributing, and number to be used in respect to floor areas and other conditions.

Some authorities give a fourth class of fire that includes fires in automobiles, internal-combustion motors, motorboats, and similar equipment.

For the use of volatile-liquid and carbon-dioxide-type extinguishers, the Underwriters' Laboratories, Inc.,[8] recommend the following apparatus:

Vaporizing liquid extinguishers are first-aid fire appliances utilizing as extinguishing agent a specially treated vaporizing, nonconducting liquid (carbon-tetrachloride base) with important components for depressing freezing point, avoiding corrosion, etc., such liquids being supplied by manufacturers for use in their extinguishers. These extinguishers must be partially discharged and refilled yearly. In using extinguishers of this type, especially in unventilated spaces, such as small rooms, closets, or confined spaces, operators and others should take precautions to avoid the effects which may be caused by breathing the vapors or gases liberated or produced. Extinguishers made of brass unless otherwise listed.

The 1-qt. size (classification B-2, C-2) is especially adapted for automobile and motorboat use. It can be handled readily by women.

The 1¼, 1½, and 2-qt. sizes (classification B-2, C-2) are intended for use largely in industrial establishments.

The 1-gal. and larger sizes (classification B-2, C-1) are especially intended for use in electrical power stations and the like and for special industrial conditions where consideration has been given to large quantity of liquid and where such devices are usually operated by men familiar with their use and where efficient supervision prevails.

Carbon dioxide is a nonconductor, and its properties are such that when air is displaced by it or mixed with it in suitable proportions it is effective on classes B and C fires.

In using extinguishers of this type, especially in unventilated places such as as small rooms, closets, or confined spaces, operators and others should take precautions to avoid the effects which may be caused by breathing the vapors or gases liberated or produced.

Extinguishers utilize CO_2 stored in ICC-3 shipping containers which are equipped with special cutter or seated-type valves permitting release of CO_2 gas through hand hose and nozzle.

The small sizes are provided with a handle or strap for portability and a wall hook for mounting, whereas the large sizes are mounted on two-wheel trucks. Cylinders in service should be weighed annually to detect loss of liquid by leakage, tampering, or use.

Carbon tetrachloride extinguishers have been very popular; however, the use of this liquid on a fire in a confined space is hazardous, unless the user fully understands the action of the liquids, because when carbon tetrachloride is heated it breaks up and releases several gases, including phosgene, chlorine, carbon-monoxide, and carbon dioxide.[9] The first two gases were used extensively during the World War. The following chemical formulas[10] show how carbon tetrachloride liquid breaks up into gases when sprayed on a fire or heated substance:

$$\underset{\text{(Carbon tetrachloride)}}{CCl_4} + \underset{\text{(Water)}}{H_2O} = \underset{\text{(Phosgene)}}{COCl_2} + \underset{\text{(Hydrochloric acid)}}{2HCl}$$

$$\underset{\text{(Carbon tetrachloride)}}{2CCl_4} + \underset{\text{(Oxygen)}}{O_2} = \underset{\text{(Phosgene)}}{2COCl_2} + \underset{\text{(Chlorine)}}{2Cl_2}$$

$$\underset{\text{(Carbon tetrachloride)}}{3CCl_4} + \underset{\text{(Ferric oxide)}}{Fe_2O_3} = \underset{\text{(Phosgene)}}{3COCl_2} + \underset{\text{(Iron perchloride)}}{2FeCl_3}$$

$$\underset{\text{(Carbon tetrachloride)}}{2CCl_4} + \text{Heat} = \underset{\text{(Tetrachlorethylene)}}{C_2Cl_4} + \underset{\text{(Chlorine)}}{2Cl_2}$$

$$\underset{\text{(Carbon tetrachloride)}}{CCL_4} + \underset{\text{(Water)}}{2H_2O} = \underset{\text{(Carbon dioxide)}}{CO_2} + \underset{\text{(Hydrochloric acid)}}{4CHl}$$

The quantity of these gases generated in a fire depends on the amount of carbon tetrachloride required to extinguish the fire. The physiological effect of breathing the gases depends on the concentration of gas or gases in the atmosphere, the length of exposure to them, and the physical condition of the person breathing them. A person forced to breathe air containing 0.009 percent of phosgene by volume or 0.09 percent of chlorine will be killed in a short time.[11] Breathing air containing 0.2 to 0.25 percent of carbon monoxide may cause death in 30 minutes to 2 hours,

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[1] Reprinted from Bureau of Mines Information Circular 7150.

[2] Mining Engineer, Health and Safety Branch, Bureau of Mines Safety Station, Dallas, Texas.

[7] Underwriters' Laboratories, Inc., List of Inspected Fire Protection Equipment and Materials; January 1939, pp. 38-39.

[8] See footnote 7.

[9] Fieldner, A. C., and Katz, S. H., Gases Produced in the Use of Carbon Tetrachloride and Foamite Fire Extinguishers in Mines: Bureau of Mines Rept. of Investigations 2262, 1921, pp. 2-4.

Katz, S. H., Gleim, E. J., and Bloomfield, J. J., Carbon Tetrachloride Extinguisher on Electric Fires: Bureau of Mines Rept. of Investigations 2499, 1923, p. 6.

[10] Chemists of the American-LaFrance-Foamite Corporation, Elmira, N. Y., and the Bureau of Mines.

[11] Sayers, R. R., and DallaVale, J. M., Prevention of Occupational Diseases Other Than Those That Are Caused by Toxic Dust: Mech. Eng., vol. 57, No. 4, 1935, pp. 230-234.

Why not use your key to this "treasure house" of information

There's too little time these days to take experimental chances with anything so important as tube alloys for condensers and heat exchangers...particularly when such a rich fund of practical knowledge exists in the files of The American Brass Company's Technical Department.

In these files and through the men who have assembled the facts, you have access to actual operating experience, to case histories, to the operating data on various alloys including all the Anaconda Alloys such as: Arsenical Admiralty, Super-Nickel, Ambrac and many others.

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and 10 percent of carbon dioxide in air may produce serious symptoms almost immediately.[12] Other gases likely to be generated when carbon tetrachloride extinguishers are used on a fire are hydrochloric acid gas, tetrachlorethylene, and carbon tetrachloride vapors, in addition to the gases that would be generated by the burning substances if no carbon tetrachloride were applied. Therefore, extreme care should be taken to insure that any person who uses a carbon tetrachloride extinguisher does not inhale the fumes. The printed warning on many carbon tetrachloride-type extinguishers states: "Avoid Inhaling the Fumes." The Underwriters' Laboratories, Inc.,[13] give the following data on the use of volatile-liquid extinguishers:

Extinguishing effect of the liquid is due primarily to the smothering action of the heavy blanket of vapor developed by the heat of the fire. One quart of liquid produces about 10 cubic feet of vapor. The liquid has little cooling effect, due to its low specific heat and low heat of vaporization. It is a nonconductor of electricity. It is effective on small flammable liquid or grease fires (class B) and fires involving electrical equipment (class C). Compared to foam on class B fires, the vapor blanket is impermanent, and it is possible for reflashes to occur over the entire area if the fire was not fully extinguished.

[12] Bureau of Mines, Manual of First-Aid Instruction: 1940, pp. 61-62.
[13] Underwriters' Laboratories, Inc., Card Data Service, Serial No. UL165, June, 1939.

Classification: Regardless of size, hand-vaporizing liquid extinguishers carry maximum classifications of B-2, C-1, and are not recommended for class B fires of more than 6 square feet in area. They should not be applied to fires involving sulphuric acid. They are relatively ineffective on fires involving deep-seated embers but may be of value on small surface fires involving wood, paper, textile materials, rubbish, etc.

If carbon tetrachloride is used on a fire the liquid should be sprayed from the windward side through a window, door, or other opening. For example, a person should not enter an automobile and spray the liquid onto a burning cushion. The tremendously irritating effects and the odor of the fumes from carbon tetrachloride can be demonstrated by placing 2 teaspoonfuls of gasoline into a small-diameter shallow pan and igniting the vapors. A relatively small quantity of smoke is given off by the burning vapors, but if 1 teaspoonful of carbon tetrachloride is added the fumes and smoke become dense (DO NOT take a deep breath of these fumes). A second, or perhaps a third, spoonful of carbon tetrachloride must be added to the pan of burning gasoline before the flames are extinguished.

It is claimed that the irritating gases generated by the use of volatile-liquid extinguishers will force a person to leave the fire area; they may drive him out just when a little more work might have extinguished the flame. If the user has been warned previously that irritating vapors will be produced, he can take the necessary precautions before attempting to extinguish the fires.

This experiment does not indicate the amount of carbon tetrachloride necessary to extinguish a gasoline fire; a much smaller amount would be effective if it were applied properly by spraying. As stated, it is the noninflammable vapors, not the liquid, that extinguishes the fire. The amount used in the experiment indicates the quantity that might be necessary to make a given quantity of gasoline liquid noninflammable, which is the usual method of making cleaning solvents safe. The experiment should not be continued in a small room for any length of time without ventilating the room, otherwise the fumes generated may be irritating or may cause illness.

All safety engineers and fire departments desire that each person should understand fully what he is doing when he is using a fire extinguisher that may cause the formation of gases of a toxic nature or may be employed on an electric fire.

Fire extinguishers containing carbon dioxide gas under pressure are becoming popular and are recommended for class B and C fires. Carbon dioxide is a noninflammable gas weighing 1½ times as much as air, therefore it will tend to hang in a cloud close to the ground or other low place and, when applied from the windward side at the base of a flame, will smother a fire by excluding the air in essentially the same manner as if a wet blanket had been used. Air containing more than 10 percent carbon dioxide can be breathed only a short time.

Several carbon dioxide fire extinguishers are on the market. In some plants large banks of cylinders are arranged to flood a machine room or area automatically with carbon dioxide when a

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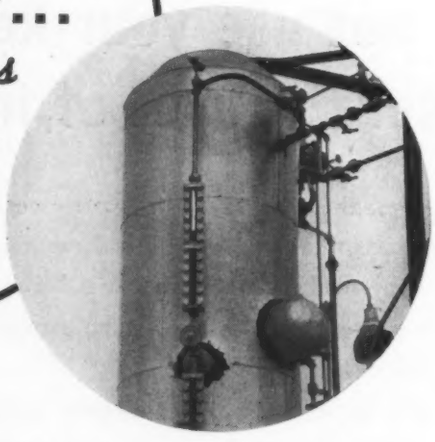
Reflex Gages

VISIBILITY...
...obviously excellent

DURABILITY...
...proved by years of service



What you see close to is what you see at a distance — a solid black section to indicate liquid, almost white to indicate empty space above the liquid. The contrast is as powerfully eye-catching as a red flag. At a glance—and a quick one — you know where the liquid level is.

As for the durability of Jerguson Gages, always keep in mind that these are designed and made for refinery service. Forged steel and alloyed steel parts are used where the stresses come; the glass is carefully tempered. The exclusive U-Bolt assembly gives added strength.

Send for literature giving full details.

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ANOTHER

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GASOLINE REFINING PROCESS

PLANT

by FOSTER WHEELER goes into operation.

This plant will process 28,000 barrels per day of cracked and straight run gasolines.

It . . 1 completely removes mercaptan sulphur
2 increases octane number
3 increases lead susceptibility
4 eliminates objectionable odor
5 renders product doctor sweet
6 makes treating pay dividends

This process is engineered, designed, fabricated and constructed with unit responsibility by Foster Wheeler. The process is licensed by the Shell Development Company.

FOSTER WHEELER CORPORATION, 165 BROADWAY, N. Y.

FOSTER FW WHEELER

It kills HIDDEN fires!

Reaches around corners . . . behind obstructions!

MAYBE your extinguishers can handle most fires . . . can snuff out ordinary blazes. But what about the *extra-dangerous* fires?

LUX extinguishers beat these blazes to the punch, with a blast of carbon dioxide gas, amazingly effective extinguishing agent.

For example, LUX can kill hidden fires . . . those blazes that lurk behind obstructions which baffle liquid-stream extinguishers. LUX gas leaves the nozzle expanding 45,000%! This terrific force drives the gas into every inch of fire area. LUX penetrates through tiny openings, scoots around corners. *It kills fires you can't even see!*

This is a fire fighting *plus* that you get with LUX—both portable extinguishers and built-in systems. It is one more reason why LUX protection means *added* protection, greater safety.

Here are the *PLUS* values in fire-fighting

1. LUX carbon dioxide gas is one of the fastest known extinguishing agents.
2. LUX extinguishers are effective on both electrical and flammable liquid fires.
3. LUX gas is clean, non-damaging, non-contaminating, non-toxic.
4. *45,000% expansion* drives LUX gas throughout fire area, despite obstructions.
5. Annual recharging is not necessary with LUX. Simply weigh periodically.
6. LUX service depots are maintained in principal cities.

LUX SNUFFS OUT FIRE

Walter Kidde & Company
Incorporated
917 West Street, Bloomfield, N. J.

fire occurs. As carbon dioxide dilutes the oxygen in the air or may even exclude it, extreme care must be taken that enough oxygen is present to support life before entering a room where a fire has occurred or where carbon dioxide has been used to extinguish the blaze. (The use of a carbon dioxide-type extinguisher on the cotton fire can be demonstrated with the trough, keeping one 5-pound and one 15-pound extinguisher with the exhibit at all times to take care of any fire emergency that might arise in connection with the experiment.)

Regardless of the type of agent used to extinguish a fire in a confined area, no person should enter the area without proper respiratory protection, unless it has been thoroughly ventilated. Canister-type gas masks do not give adequate protection against an atmosphere containing more than 2 percent of most gases and give no protection whatsoever against an atmosphere deficient in oxygen; this fact is important, as numerous persons have lost their lives by wearing canister-type gas masks when fighting fires.

Small fires about the home, such as those in small pans of burning grease, and small gasoline, oil, and automobile fires can be extinguished with ordinary baking soda (bicarbonate of soda) by sprinkling the soda over the small pan or blaze. WARNING: Do not use flour, as flour dust is inflammable and under some conditions explosive. Although salt may extinguish a small fier, it contains water, which may cause the grease or oil to splash, hence should be used with caution.

The effectiveness of bicarbonate of soda can be demonstrated by placing a small quantity of gasoline in a frying pan (a glass frying pan is preferred) about 6 inches in diameter, igniting the gasoline, and sprinkling bicarbonate of soda into the pan until the flame is extinguished. The quantity necessary to extinguish the blaze depends upon how it is applied; 1 to 2 tablespoonfuls generally suffices.

A combination of sodium bicarbonate with certain compounds and carbon dioxide gas under pressure in a fire extinguisher has proved effective on many gas and oil fires. It is sold under a familiar trade name. In an extinguisher of this type sodium bicarbonate is treated with a compound to prevent caking. The extinguisher excludes air from the fire and insulates one layer of inflammable gas, thus preventing the heat from being conducted to the next layer. In the presence of heat bicarbonate of soda releases carbon dioxide gas, which also assists in extinguishing the fire. The Underwriters' Laboratories, Inc., give the following description of the scope of this extinguisher:[14]

Scope: This discharge of the powder compound is effective in class B and C situations, where the dust cloud may dilute air adjacent to the seat of the fire or separate the flames from the burning material. It is especially effective on flat surface fires where the sweeping action of the dust cloud can be most advantageously employed. While little practical cooling action is provided by the dry powder, the extinguishers may be of value on surface fires involving paper, wood, textiles, etc. They are not effective on deep-seated fires or embers.

The powder cloud is transient in its

[14] See footnote 13.

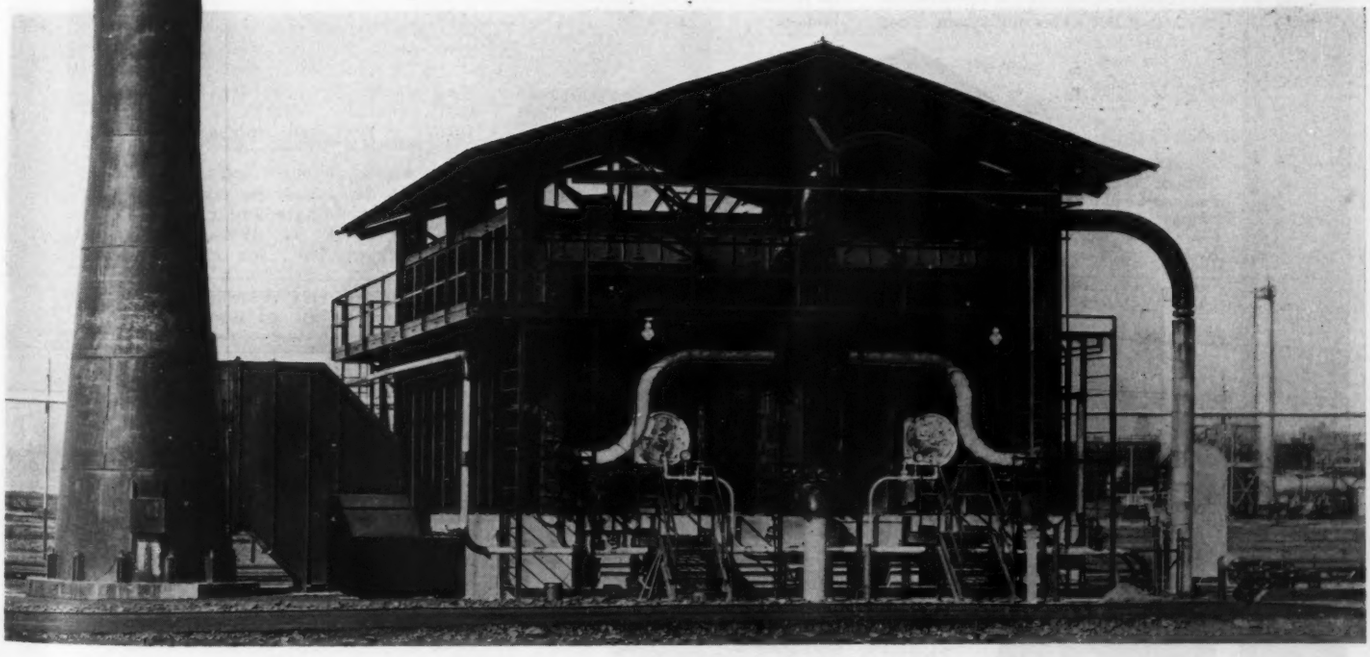
OIL REFINERY FURNACES

REPEAT ORDERS PROVE ACCEPTANCE

One major refiner has purchased ten Foster Wheeler furnaces during the past eighteen months to serve important processing plants. Refinery records tell a graphic story of superior performance and low maintenance cost of Foster Wheeler furnaces as compared with other furnaces.

Every Foster Wheeler furnace carries a performance guarantee backed up by the reputation of an engineering organization which has designed and constructed more than one thousand similar units.

These furnaces are competitive in price. Our engineers are available to tell you about the many modern design features which insure long life and low cost of operation.



Foster Wheeler Corporation, 165 Broadway, New York, N. Y.

FOSTER FW WHEELER

extinguishing action and does not form a blanket, as in the case of foam, on class B fires, thus permitting reflashes over the entire area if the fire has not been completely extinguished. It is, however, equally effective on oil or alcohol types of flammable liquid fires.

For many years fire extinguishers that generate foam have been used for extinguishing oil fires and have been effective when the foam was applied correctly. Fire extinguishers of this type contain two liquids; one may be dark brown and the other white or clear, or both may be white or clear, depending on the manufacturer. The liquids are kept in separate containers and allowed to mix only at a point close to the blaze, because the foam that is generated by mixing the solutions will break up if forced through a hose or pipe of any length. One manufacturer uses a solution of water, sodium bicarbonate, and secondary extract of licorice root with a solution of aluminum sulfate and water. Some manufacturers use ground glue and glucose instead of the licorice-root extract to make the bubbles tough. (The chemical reaction[15] involved in generating the foam is $Al_2(SO_4)_3 + 6NaHCO_3 = 3Na_2SO_4 + 2Al(OH)_3 + 6CO_2$, and the carbon dioxide is trapped in liquid bubbles.)

A few years ago a large tank of oil on the Pacific Coast ignited and enough foam was pumped into the tank to fill it several times without extinguishing the fire. To determine the reason for the failure of the foam, several oil companies rebuilt the tank and conducted numerous experiments. It was found that as the foam dropped from the mixing chamber into the flaming oil it was broken up in such a manner that only a small quantity spread over the surface of the oil. After much experimentation a tube of reinforced asbestos was fastened to the end of a gooseneck, which was long enough to reach above the top of the tank. When a fire occurs in an oil tank the gooseneck is wheeled to the windward side and raised so the asbestos tube can be dropped inside the tank. The solutions are pumped into the gooseneck and generate foam which flows through the asbestos tube that is probably submerged in the oil. The tube then rises to the surface of the burning oil, and a blanket of the foam spreads over the surface, extinguishing the fire. One manufacturer of fire equipment has placed on the market spiral chutes that may be fastened on the inside of the tank to conduct the foam from the mixing chambers at the top of the tank to the surface of the burning oil without breaking it up.

The instructions that are given for the use of foam extinguishers of any type state that the foam should not be directed into the burning liquid but should be applied so as to spread over the surface in the form of a blanket.

[15] Fieldner, A. C., and Katz, S. H., Gases Produced in the Use of Carbon Tetrachloride and Foamite Fire Extinguishers in Mines: Bureau of Mines Rept. of Investigations 2262, 1921, 6 pp.

Visibility

PLUS MECHANICAL STRENGTH

When you install a PYREX Broad Red Line Gauge Glass, you can be sure of two things. It will give you greater visibility and it is there to stay for a long time.

PYREX Gauge Glasses are made from tough PYREX brand Industrial Glass. They resist the corrosive action of hot water and steam. They resist the shock of sudden temperature changes. They are machine drawn to uniform accuracy that eliminates installation strains.

The next order you place for gauge glasses try PYREX glasses with the broad red line. They are stocked by all leading steam and mill supply houses.

"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works, Corning, N. Y.

CORNING Glass Works Corning, New York

Pyrex Gauge Glasses

Electric Fires

The first essential in a fire in or around electric equipment is generally to cut off the source of electric energy. (This fact indicates the desirability of proper openings or switches in all power lines so that electric current can be disconnected with minimum delay.) Although certain extinguishing substances may quench the electric arc, the arc will generally reform when the substance is removed, unless the power is cut off.

As stated, carbon tetrachloride, carbon dioxide, and some combinations of sodium bicarbonate and carbon dioxide are approved by the Underwriters' Laboratories, Inc., for use on electric fires.

When properly handled by experienced men, a fog of water can be applied safely to electric fires, although this technique is risky for the amateur.

It is stressed again that unventilated fire areas should not be entered even when no fire extinguisher has been used, unless the proper type of respiratory protective equipment is worn, and it should be remembered that a canister-type gas mask affords little or no protection.

Explosions

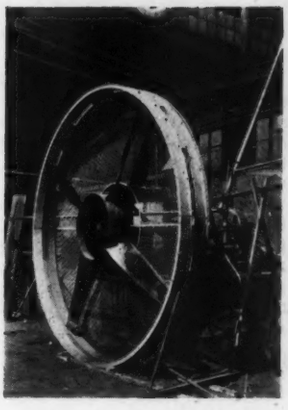
A brief discussion of the explosion disaster at the New London School, New London, Texas, may assist not only in preventing similar disasters, but also in explaining why many explosions occur in the petroleum industry. Moreover, it should help to explain the construction of electric equipment that bears the permissible plate of approval of the Bureau of Mines or the approval plate of the Underwriters' Laboratories, Inc.

Although it is impossible to state exactly what has caused many explosions, competent investigators usually are able, after the proper investigation, to determine the probable cause and

Pilot plant cooling tower—commercial size

COOLING TOWER RESEARCH

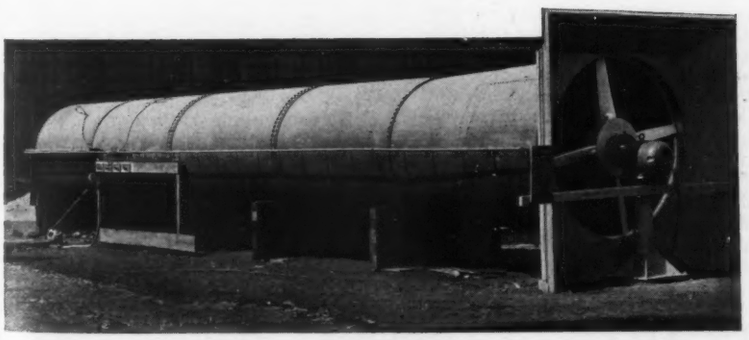
Lowers Cooling Costs



Experimental fan construction

Constant research in refinery processing, and unrelenting research in processing equipment, go hand in hand toward greater effectiveness and lower costs. The research laboratory and most of the testing equipment of Foster Wheeler is at its Carteret plant. The cooling towers which it produces are the result of experience extending back more than forty years.

Low head mechanical draft towers of exceptional compactness and low water loss have been developed for refineries throughout the country. Comprehensive engineering study given each installation has brought about such wide acceptance that more than one-half of these Foster Wheeler towers have been used in oil refinery work.



Wind tunnel at Carteret—fans tested for capacity, efficiency, and sound level

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source of the material that has burned or exploded, as well as the igniting agent.

Immediately after the New London School disaster, some engineers of the Federal Bureau of Mines, among other experts, made a detailed investigation, and the results of this investigation were published in Bureau of Mines Report of Investigations 3365. This report contains information of a scientific nature and probably has saved petroleum companies and parents whose children were killed in the explosion many thousands of dollars in useless and expensive lawsuits, because the work done by the Bureau engineers showed that gas did not seep into the building from nearby wells, gas lines, or storage tanks. The report states:[16]

The investigation revealed that the explosion was not caused by high explosives, seepage of hydrocarbon vapors or liquids from nearby oil wells or pipe lines into the space under the first floor, or combustibles from the sewage system; therefore, by a process of elimination the source of combustibles appeared to be natural gas supplied as fuel to the school through lines and services installed in the space under the floor.

The only evidence contradictory to the general conclusion that the explosion was due to an accumulation of highly explosive natural gas-air mixture in the space under the first floor was given by a janitor in the school, who stated that he entered the space through the door at the south end on the morning preceding the explosion and struck a match. No explosion resulted when the match was ignited, and the janitor did not observe any unusual condition.

This evidence indicates that at one spot in the south end of the space under the floor natural gas was not present in explosive proportions a few hours before explosion. However, it is not at all certain that appreciable percentages of natural gas were not present there also. There are numerous oil wells and pipe lines in this district, and the air is permeated with hydrocarbon odors much of the time; therefore, the presence of natural gas in the space, in proportions below the lower explosive limit, might not have been detected.

Mixtures below the lower explosive limit that do not contain enough natural gas to cause explosions would cause a lighted match to burn with a longer flame, but the janitor may not have noticed this, or, if he did, he probably was not aware of its significance.

The fact that explosive mixtures were not present in the south end does not contradict the general conclusion that natural gas caused the explosion, because evidence indicates that the highest concentration of natural gas was at or near the north end and near the place where the explosive mixture was ignited. * * *

The floor plan of the building was laid out in the form of the letter E, with the back of the letter forming the front of the building and facing the west. * * *

The natural ground level was higher at the front of the building and sloped downward toward the rear. When the two wings were added, classrooms were provided at the rear of the unexcavated space, and the floors in these rooms were placed on the earth with no unventilated spaces underneath.

* * * The consensus of opinion of those who were present was that when the explosion occurred the floor, ceiling, and roof at the north end of the building were lifted upward; the walls were pushed outward, and when the force of the blast was spent the floor, ceiling, and roof fell in a tangled mass. Toward the south end there was evidence of greater violence.

When an explosive mixture of gas and air is ignited, the rapid chemical reaction that takes place heats the products of combustion to a very high temperature. As a result, if the gases are not confined they expand instantaneously to 3 to 6 times their original volume, and if they are confined their pressure is increased with like rapidity. When such an explosion of a natural gas-air mixture, initially at atmospheric pressure, takes place in a space where there is no opening, the pressure developed, measured in atmospheres, is approximately equal to the ratio of the highest absolute temperature of the products of combustion to the initial temperature of the gas mixture. If the pressure within the space exceeds the ability of the walls to resist it, the chamber is ruptured and the heated gases travel from the high-pressure area to the outside atmosphere along paths of lower resistance and pressure. Therefore, damage resulting from an explosion in a chamber whose walls offer considerable resistance is not localized, but may extend over an area much greater than that in which the explosive mixture was present originally. The more rugged the walls and the smaller the areas of the openings in them, the higher will be the pressure at which the chamber is ruptured and the greater the resulting damage.

The explosion originated under the first floor and covered the entire space that extended from the north end and along the front of the building to the south end. This conclusion was reached after a study of the visual damage to foundation walls and the evidence obtained from various witnesses, who described the directions of the force of the explosion.

The plans show that the space under the first floor had four small ventilators 11 by 22 inches in size (one at the north end, one at the south end, and two on the east side) and two doors, each 4 by 4 feet. The door at the south end was said to have been closed. According to information, the door at the north end, opening into the manual-training room was usually left open because some of the lumber used in the manual-training room was stored just inside the door. This doorway was in the wall separating the manual-training shop from the space under the floor of the main building, and its bottom edge was about 4 feet above the floor level of the shop.

From a practical standpoint, the space below the floor was a closed chamber; no ventilation was provided in the west wall of the building, which was 254 feet 11 inches over all, in length, and the four ventilators (two in the east wall and one each in the north and south walls) did not allow enough natural draft to ventilate a chamber of this volume and shape. The reinforced concrete foundation walls and floor were poured as a unit and formed a tight barrier against the release of pressure generated by the explosion, until the pressure reached sufficient magnitude to rupture the foundation walls and burst the floor.

Witnesses testified that the ignition of gas took place when the electric sander was started in the manual-training room. It may seem strange that a person could witness such a forceful explosion and live to tell about it. In investigating explosions in coal mines and other places, Bureau of Mines engineers often are able to trace the source of ignition, because at that point there usually is less force or evidence of force than at distant points. If an ignition takes place at one end of a long room, such as an auditorium, which is more or less filled with an explosive mixture of gas, by the time the explosion has reached the other end of the room it will probably have built up a much greater pressure than it had at the beginning, simply because additional quantities of gas have been heated and expanded; undoubtedly this was what happened at the New London School.

Fires and explosions caused by ignition of inflammable vapors by an electric arc are not as common in the petroleum industry as they have been in the past; however, they still occur and are caused by the use of unapproved or nonpermissible or open types of electric equipment.

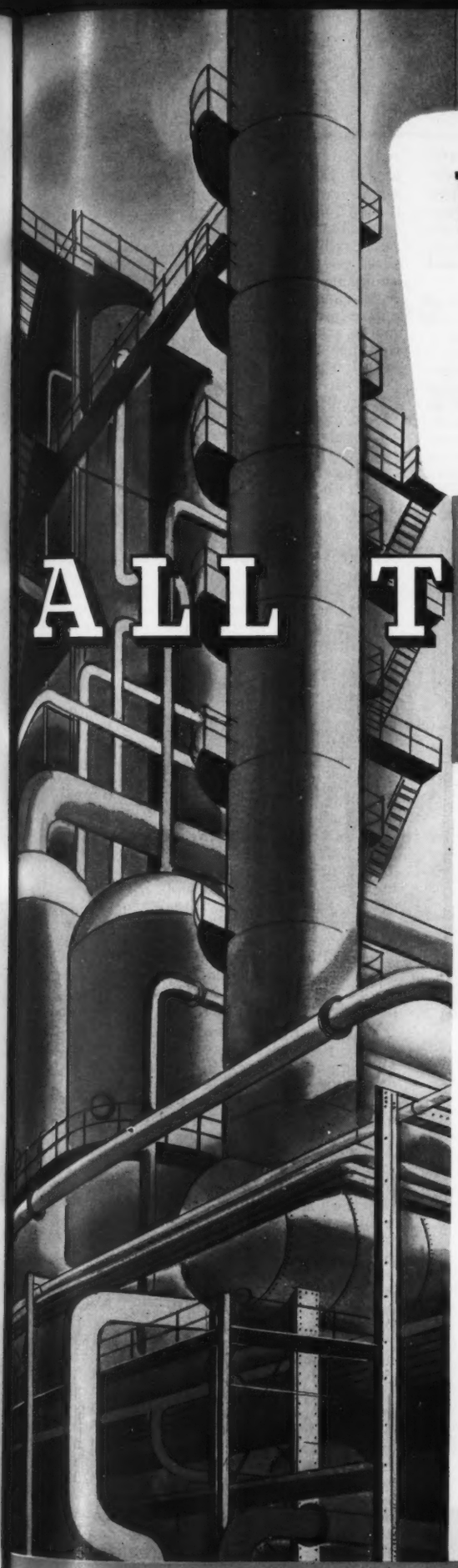
Records are not available of the fires caused by electric arcs in the petroleum industry; however, during the past 10 years electricity is known to have been the igniting agent in 110 explosions that killed 573 men in the coal mines of the United States.[17]

To illustrate various sources of ignition of explosive gas by electric equipment, Bureau of Mines engineers have designed a small portable explosion chamber composed of a heavy glass cylinder approximately 7 inches in inside diameter and 12 inches long. This hollow glass cylinder is clamped between two metal plates that have openings approximately 6 inches in diameter and is mounted vertically on a square, hollow, wooden base. The opening in the bottom plate is designed so that various plates containing different electric devices can be clamped in the cylinder in this opening and electric connections made. The opening in the top plate is equipped with a metal ring so that a thin piece of paper may be clamped over the opening. Thus, electric equipment may be sealed inside the glass cylinder. By means of a small plunger-type hand pump (which can be filled to a predetermined point with inflammable gas from a high-pressure steel cylinder), a measured quantity of natural gas can be forced into the glass cylinder through small openings in the metal plates which are connected to the pump cylinder. (This chamber is in part a small replica of the large testing tank of the Federal Bureau of Mines at Pittsburgh, Pa.)

A small (0.01 horsepower) electric motor using carbon brushes can be placed inside of this chamber and sealed. When the current is turned on,

[16] Parker, D. J., Jones, G. W., Hill, H. B., and Wade, Gustav, Explosion in School Building at New London, Texas, March 18, 1937: Bureau of Mines Rept. of Investigations 3365, 1938, 29 pp.

[17] Harrington, D., and Fene, W. J., Coal-Mine Explosions and Coal- and Metal-Mine Fires in the United States During the Fiscal Year Ended June 30, 1938: Bureau of Mines Inf. Circ. 7048, 1939, 21 pp.



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the arc from the brushes ignites the inflammable gas mixture in the glass cylinder, generating pressure which is released by rupturing of the paper diaphragm.

The motors used in the field to set up the bolts on tanks, for drill holes, and for innumerable other uses are much more powerful, and if they are equipped with open brushes or unapproved-type switches, controllers, or cables are likely to cause an arc that will ignite gas as readily as the smaller motor used in this experiment.

The demonstration motor is designed so that by screwing a metal plate over the opening leading to the brushes it will have essentially the features of a standard approved or permissible motor for emergency use in an inflammable mixture of gas. When the plate is screwed onto the back of the demonstration motor, thereby making it enclosed or "permissible," and the motor is placed inside of the chamber filled with an explosive mixture of gas and air, it can be operated at full speed, even started and stopped without igniting the inflammable-gas mixture around it. The safety of approved or permissible electric equipment, other than portable hand lamps, depends on enclosing the brushes and arcing parts in a case strong enough to withstand any explosion that might occur on the inside and on having all openings leading into the case so small and of such length that the flame or gases escaping from an inside explosion will be cooled to a temperature below that required to ignite gases on the outside. All permissible electric equipment, other than portable electric lamps, have large openings sealed with plates that have milled bearing surfaces, and no gaskets are permitted to be used, except where the threaded surface will accomplish the same purpose as the milled surface; gaskets are not permitted because they may blow out and hence leave openings through which flame or highly heated gases may escape, thus igniting gases in the atmosphere surrounding the equipment. The area between the shaft and the bearings must be of a definite dimension and design known to prevent escape of flames or highly heated air or gases and the cables leading into the casing must be packed heavily with specified packing. No long or large spaces are permitted in the casings; thus excessive pressures are avoided if an explosion occurs within the case.[18]

Permissible electric equipment is NOT VAPORPROOF, and it is believed that no piece of electric equipment on the market is vaporproof. So-called "vaporproof fixtures" are neither vaporproof nor explosion proof; however, electric equipment of essentially all types is made explosion proof, and such equipment generally bears the approval either of the Underwriters' Laboratories, Inc., or the Bureau of Mines.

With changes in temperature or barometric pressure, every piece of electric equipment is likely to "breathe" in or out; thus it is possible for a mixture of inflammable gas to accumulate within a piece of electric equipment. If an arc occurs in such a mixture an explosion will take place, but if the equipment is made and maintained in a "permissible" manner the flame cannot be transmitted to the atmosphere surrounding the equipment. In the Bureau of Mines method of testing electric equipment for permissibility, holes are drilled in the cases of the motor, controller, switches, and other arcing devices of the machine tested so that these parts can be filled with an explosive mixture of natural gas. The holes are plugged, and the equipment is placed in a large chamber filled with an explosive mixture of the same gas. A spark plug in the case ignites the gas inside, and if during 10 or more tests the case ruptures or permits flame to travel to the outside and ignite the outside explosive mixture, or if an excessive pressure is noted, the equipment is not approved.

Bureau of Mines engineers do not know of a single ignition of an inflammable atmosphere of gas and air by a piece of permissible electric equipment that was being used and maintained properly; however, equipment that has been approved by the Bureau of Mines or Underwriters' Laboratories, Inc., has caused explosions when NOT PROP-

[18] For the construction of permissible equipment, see the following Bureau of Mines publications: Illsley, L. C., and Gleim, E. J., Suggestions for the Design of Electrical Accessories for Permissible Mining Equipment: Bull. 258, 1926, 47 pp.; Clark H. H., Permissible Explosion-Proof Electric Motors for Mines, Conditions and Requirements for Test and Approval; Tech. Paper 101, 1915, 17 pp.

Safety engineers and electricians who are interested in making inspections of such equipment are referred to Gleim, E. J., and Freeman, H. B., Maintenance of Electrical Mine Equipment from the Viewpoint of the Safety Inspector; Bureau of Mines Tech. Paper 537, 1932, 22 pp.

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ERLY MAINTAINED AND USED. Only when approved or permissible electric equipment is maintained in the same condition that it was when received from the manufacturer, except for ordinary but not excessive wear, can either of these organizations guarantee that it may not cause ignitions, hence it is imperative that approved or permissible equipment be kept in the best possible repair, that all parts be fully assembled and fastened in place, and that the equipment be operated with utmost care.

Many fires and explosions have occurred in the petroleum industry because of poor installation of electric wires. The wiring hazard around derricks in certain parts of the country is a discredit to the industry; power lines at many refineries, gasoline plants, bulk stations, and other operations have been strung where they could become enveloped in a cloud of inflammable gas or vapor in such a manner that if an arc should occur a serious fire or explosion might result. At a derrick in California a few years ago, a serious fire resulted when the joint of a drill pipe was broken and the oil splashed onto a so-called vapor-proof globe that enclosed a 200-watt, 110-volt, lighted bulb; the cold oil caused the heavy glass globe and bulb to break, and an ignition occurred.

It is reported that a refinery truck accidentally backed against a power-line pole; although no damage was done to the pole or the truck, the jar caused the wires to swing and form an arc which ignited a cloud of gas. A somewhat similar ignition was reported in connection with a gas-pipe-line repair job.

Poor insulation on drop cords and other defects in wiring have been responsible for the electrocution of many workmen and for the electric arcs that have started many oil fires.

The Bureau of Mines demonstration chamber is supplied with a base on which are fastened two vertical wires that may be made to swing together and form an electric arc when sealed inside of the chamber containing the explosive mixture of gas. The wires barely touch before the arc is formed and an explosion occurs.

Many explosions and fires have occurred because an electric arc formed when a workman changed a fuse with a load on the line or changed an electric-light globe in inflammable gas or vapor without first opening the circuit.

The Bureau of Mines demonstration chamber is equipped with a base containing a safety-type cartridge fuse that may be made to form an arc when it is inserted and removed from contact with the electric current. (The safety feature of the fuse is that it "burns out" without emitting flame from the cartridge.) When the fuse is sealed in the chamber in an inflammable atmosphere of natural gas and air and the voltage and load on the line are reduced to very small quantities, the contact ends of the fuse can be made to arc without igniting the gas, because insufficient heat is generated by the spark; however, when the load and voltage are increased to normal amounts and an arc is formed, ignition occurs immediately. This experiment explains why some persons have "gotten away" with dangerous practices involving electric equipment and natural gas and stresses the fact that conditions must be "just right" before an explosion can occur. No one knows just how much the load may be on an electric line, nor can anyone tell readily just what may be the ignition temperature of the particular gas that is present.

Every inflammable mixture has a definite ignition temperature, and ignition will not take place until that temperature is reached. The main constituent of natural gas is methane; in air it has an ignition temperature of 1260° to 1380° F., whereas some gasoline vapors may have an ignition temperature as low as 570° F., as was proved in part by the demonstration with the fuse. If Pittsburgh natural gas is used in the demonstration chamber it can be shown that some gas mixtures are not ignited at relatively low temperatures but are readily ignited at temperatures only slightly higher. When a plate to which is attached the filament from a common electric iron is sealed in an inflammable mixture and the filament heated to a red color (a temperature between 800° and 900° F.), ignition will not take place. If the length of the filament is reduced, the electric current will heat the filament to a white heat (temperature well over 1200° F.), and a violent explosion will occur. This demonstration proves that an inflammable mixture requires a certain amount of heat to cause ignition and that ignition does not occur until that amount of heat is applied or reached.

During February, 1939, two fires that resulted in one fatality and one serious

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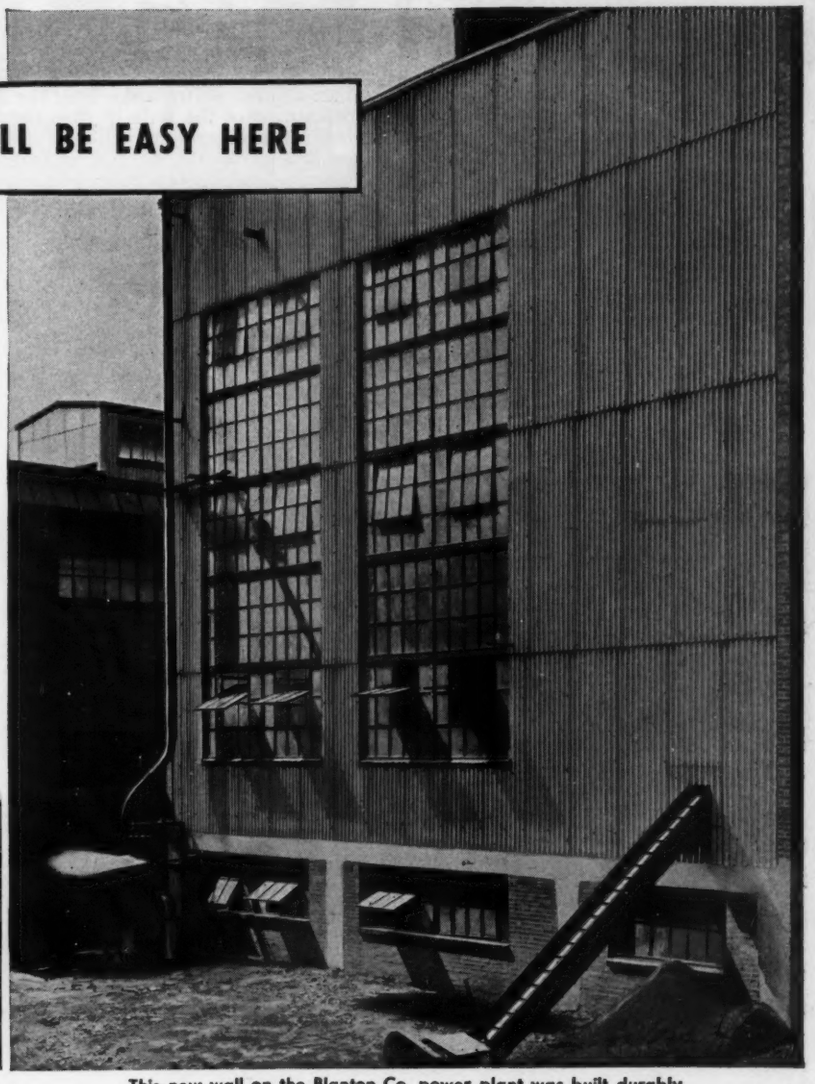

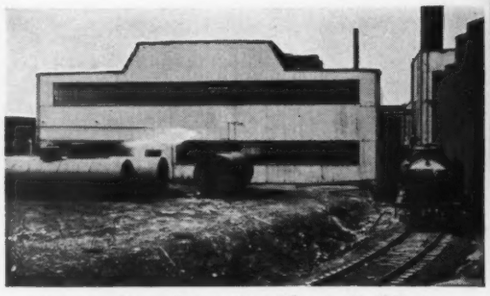

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This new wall on the Blanton Co. power plant was built durably but inexpensively with "Century" Asbestos Corrugated.

The Blanton Co., St. Louis, Mo., makers of edible oil products, planned an important plant extension. They wanted a siding material that would resist fire and weather, that could be installed easily and quickly, and would require as little upkeep as possible.

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Many materials were considered. In the end, Keasbey & Mattison "Century" Asbestos Corrugated won out. The Blanton Co. used it for the exterior side-walls of the refinery and power plant, as well as for a monitor on top of the refinery. A similar material, K&M Flat Asbestos Lumber, was used for a wall between the engine room and boiler room.

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injury occurred when nonpermissible or unapproved electric hand lamps ignited an inflammable atmosphere in which men were working. The ordinary flashlight or hand lamp is not safe for use in inflammable atmosphere unless it is constructed according to specifications similar to those required for an approval by the Bureau of Mines or the Underwriters' Laboratories, Inc.

The requirements that must be met for hand and cap lamps to pass permissibility tests are as follows:[19]

[19] Bureau of Mines, Permissible Electric Cap Lamps, Procedure in Testing, Fees Charged, and Requirements for Approval: Sched. 6D, Dec. 21, 1935, pp. 4-5.

[20] Bureau of Mines, Permissible Electric Flashlights, Procedure in Testing, Fees Charged, and Requirements for Approval: Sched. 11A, Jan. 13, 1936, p. 3.

Unless properly designed, electric cap lamps may present two sources of probable explosion hazards: (1) ignition of an explosive atmosphere by the heated filament of the bulb in case the bulb glass is accidentally broken, and (2) ignition by sparks or flashes from the battery. The bureau therefore requires the following safeguards:

(a) Safety device (design). — The headpiece shall be provided with a safety device which shall prevent the ignition of explosive mixtures of methane and air by ejecting the bulb or otherwise removing the exposed heating filament from the circuit when the bulb glass surrounding the filament is broken.

(b) Safety device (protection).—The design of the safety device and the housing which protects it shall be such that the action of the safety device is practically certain; yet at the same time the lamp shall not be too readily extinguished during normal service by the unnecessary operation of the device.

(c) Headpiece lock or seal. The lamp headpiece shall be provided with a lock or seal to prevent anyone from tampering with the safety device, the bulb, or the electrical contacts.

(d) Battery container lock.—The battery shall be enclosed in a container that is equipped with a magnetic or other equally effective lock.

(e) **Battery current restricted.**—The amount of current flow between the conductors of the cord, if short circuited just outside of the battery casing or cord armor, shall be limited by the design of the battery or by a fuse inside the locked container to such a valve as will not produce sparks that will ignite an explosive mixture of methane and air.

(f) It shall not be possible to obtain a difference of potential between any two accessible points of the cap lamp when assembled for use.

The requirements that must be met for flashlights to pass the permissible test are given below:[20]

The flashlight will be examined and tested in respect to safety only:

1. It shall be provided with a safety device which, when the bulb is broken, will prevent the heated bulb filament from igniting an explosive mixture of methane and air. The design of the safety device and the housing which protects it shall be such that the action of the safety device is practically certain; yet at the same time the light shall not be too readily extinguished during normal service by the unnecessary operation of the device.

2. The battery shall be of such design and capacity that it will not give electric sparks or arcs sufficient to ignite an explosive mixture of methane and air.

3. It shall not be possible to obtain a difference of potential between any two points on the outside of the flashlight casing.

4. Flashlights shall be durable in construction, practical in operation, and suitable for the conditions under which they are to be used.

5. Provision shall be made for sealing or adequately locking the battery container to prevent unauthorized removal of the battery underground or access to live battery terminals.

The main safety features of approved flashlights or hand lamps over those of cheaper types are their more rugged construction and the method by which the bulb is held in contact with the terminals leading to the battery. In the ordinary lamp the bulb is screwed into a socket, whereas in the permissible lamp the socket is smooth and has no threads or catches; instead, a fairly strong spring tends to push the bulb out of the socket, and the heavy glass lens, metal band, clip, or wire is arranged so as to press against the top of the glass bulb and hold it down against the spring and in contact with the terminals. When the bulb of an ordinary flashlight or hand lamp is broken, the filament will continue to burn until it has "burned up," thus the heat will last long enough and be intense enough to ignite an inflammable mixture of natural gas. With an approved or permissible-type lamp the base is thrown out of contact the in-

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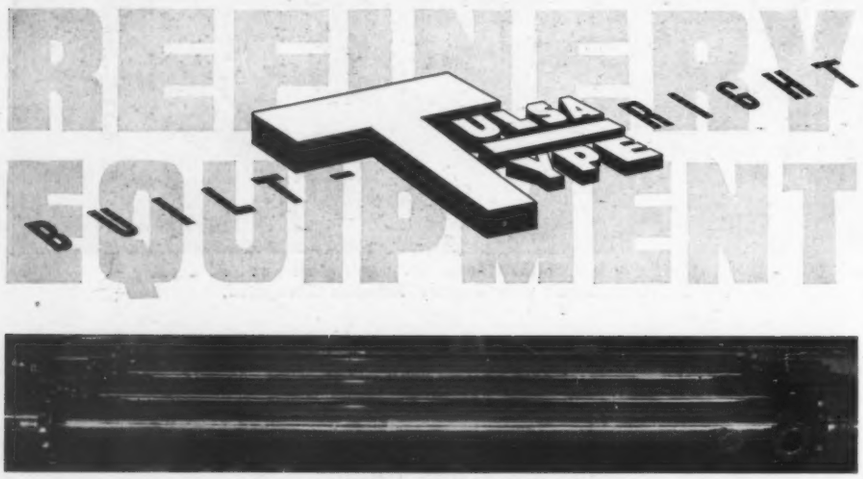

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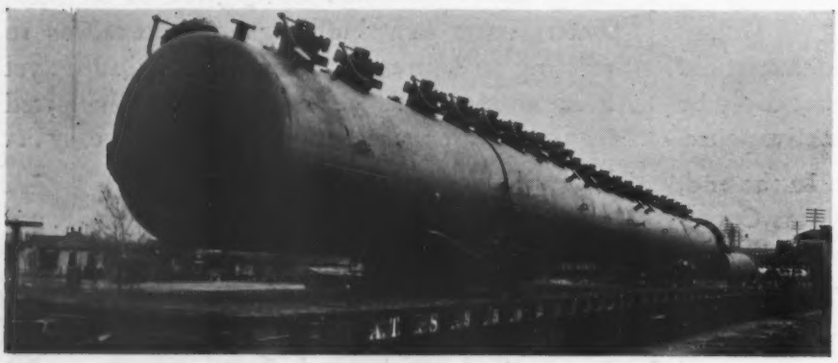

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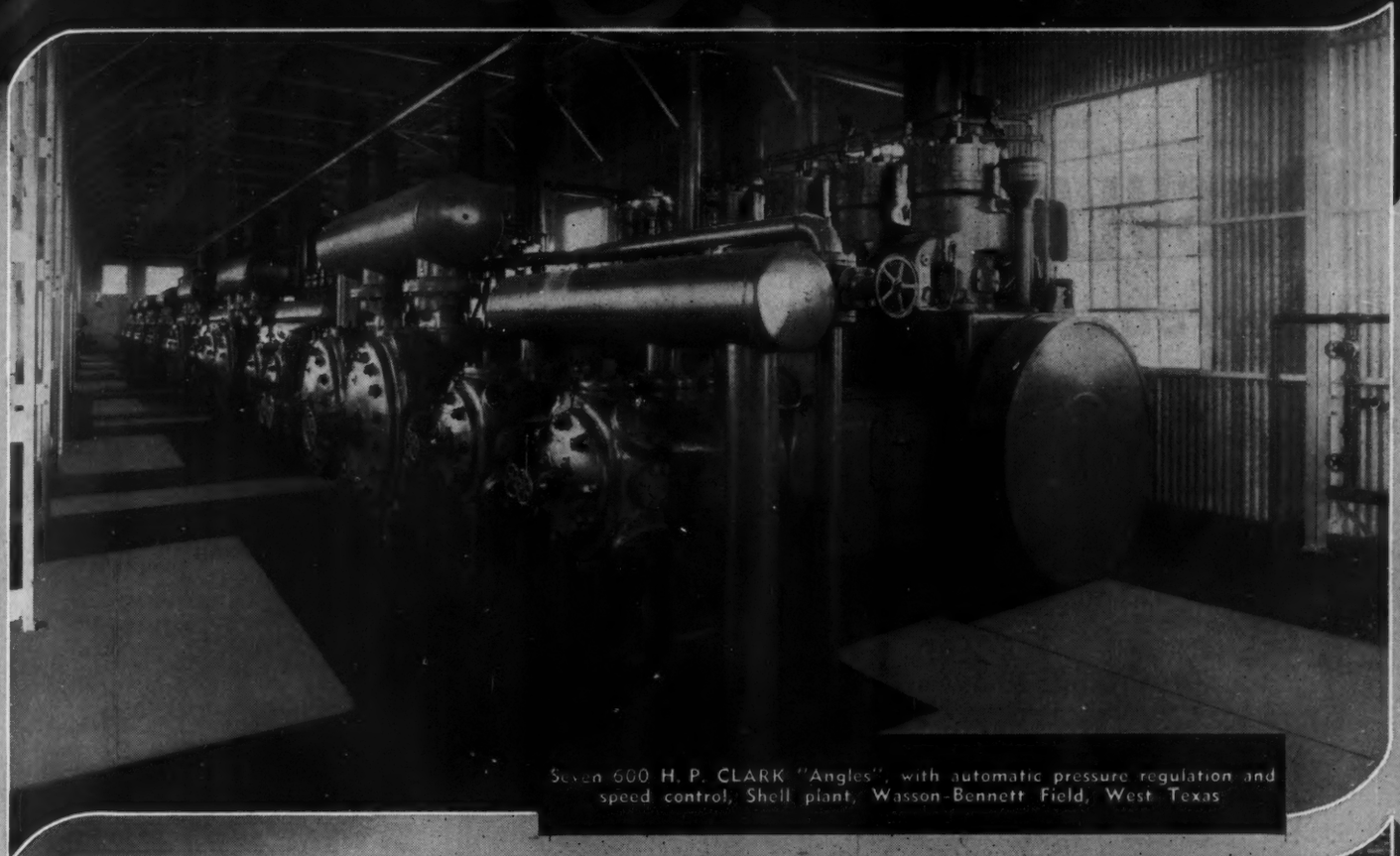
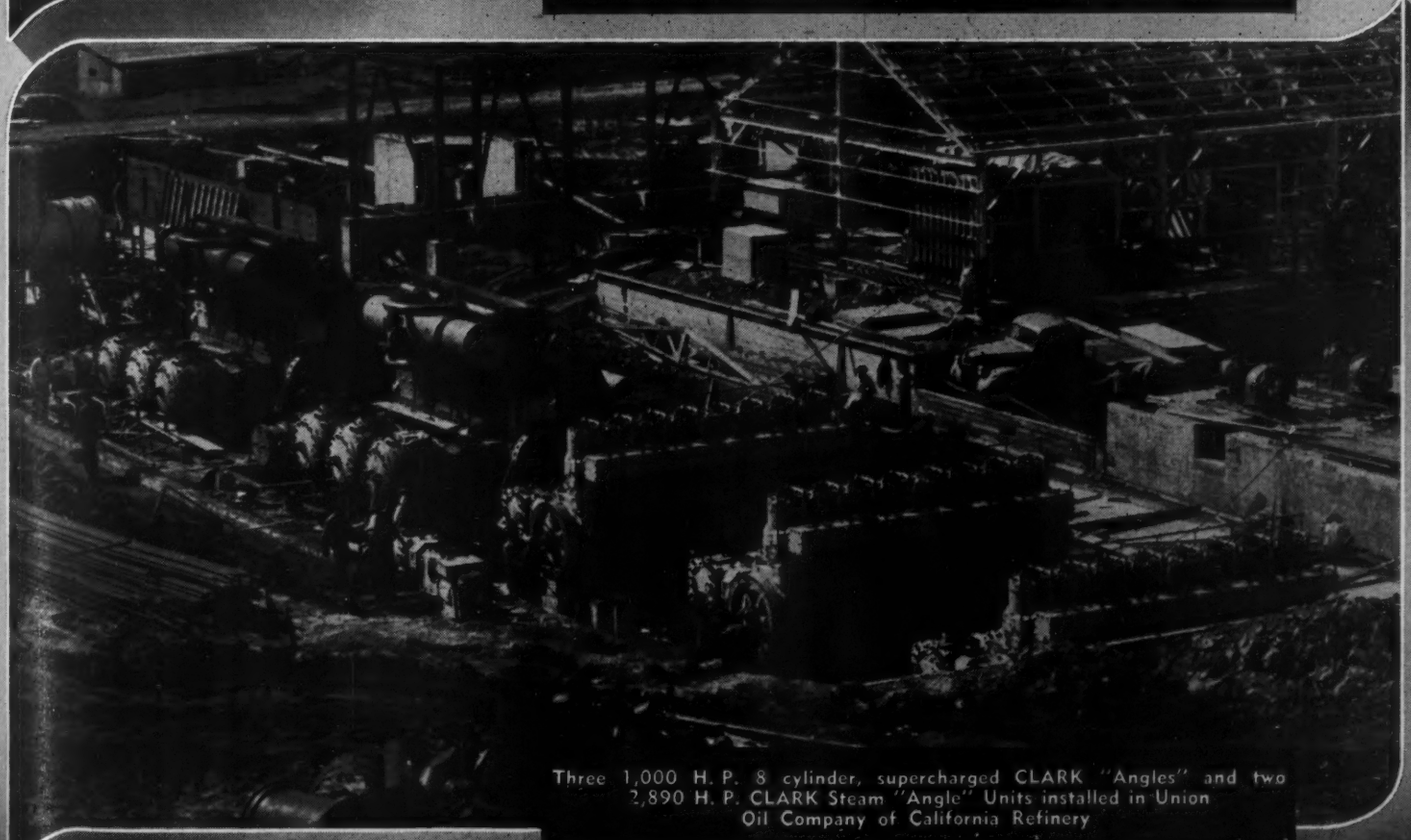


Seven 600 H. P. CLARK "Angles", with automatic pressure regulation and speed control, Shell plant, Wasson-Bennett Field, West Texas



Three 1,000 H. P. 8 cylinder, supercharged CLARK "Angles" and two 2,890 H. P. CLARK Steam "Angle" Units installed in Union Oil Company of California Refinery

stant that the bulb is broken, and the filament will not remain at a high temperature long enough to ignite the gas.

The approval list of the Federal Bureau of Mines includes unit flashlights, storage-battery cap lamps, and hand lamps using storage batteries or dry cells that have passed rigid tests as to use in explosive methane-air mixtures. Some of these lamps have also been approved by the Underwriters' Laboratories, Inc., for use in explosive gasoline vapor-air mixtures.

Although the storage-battery type of permissible cap lamp originally was developed for the mining industry, it is now being used in the petroleum industry as well. This lamp should be used in the petroleum industry not only because it is safer than other lighting equipment in an inflammable mixture of gas but also because it leaves both of the worker's hands free for sampling, climbing ladders (especially greasy and icy ones), using tools, etc., and gives superior illumination. A worker does not have to stop at intervals and move the lamp, nor does he have to work in the dark, as the direction of the illumination changes with his movements. Thus, the additional cost of the electric cap lamp is offset by increased convenience and dependability of illumination, which make possible more efficient and faster work. Many companies have found that the increased initial cost of the permissible cap lamp is more than offset also by the low cost of maintenance.

One of the plates used in the demonstration chamber is equipped with two lamp sockets designed to take the light bulbs used in permissible-type cap lamps. In one socket, which is of conventional type, the bulb can be secured in the same manner as in the socket of an automobile headlight. The second socket has no means of locking the bulb in the socket; instead it has a spring in the bottom which is compressed by pushing the base of the bulb into the socket, and the bulb is held in the socket and in contact with the terminals by a brass band placed over the top of the bulb. Back of each socket is a small plunger-type hammer that can be released to break the electric bulb. The plate, with the bulbs and hammers in place, is sealed in an inflammable mixture in the chamber and connected to a 6-volt battery. When the filament is glowing at white heat, the bulb that is inserted in the socket with arrangements similar to those for permissible lamps is broken by releasing the hammer, and the gas is not ignited because the glow of the filament ceases when the base of the bulb is ejected from contact with terminals. When the second bulb (the one in the conventional socket) is illuminated and broken, an ignition takes place immediately, and the filament continues to glow even after the explosion.

This experiment shows readily why nonpermissible or unapproved hand lamps are not safe. (Note: A similar arrangement would not make higher-voltage lamps safe because their fila ment would not cool fast enough to keep the heat from igniting the gas.)

Summary

A fire or an explosion of inflammable gas or vapor can occur only when the volume of inflammable vapor bears a definite relationship to the volume of air (oxygen) present and when the mixture of the two gases is in contact with enough heat to raise it to the ignition temperature.

Vapors or gas from gasoline and crude oils are heavier than air and may travel down a hill or valley, or they may be carried by a gentle breeze for considerable distances (several hundred feet) to a source of ignition and the flame flash back to the source of the gas or vapor.

Gasoline burns or explodes and should not be used as a cleaning agent.

Fire can be extinguished by removing the air, the fuel, or the heat. In many fires that have occurred the igniting agents have been no larger than those used in the demonstrations described in this paper.

Nonpermissible or unapproved electric equipment should not be used where the atmosphere is or may become inflammable.

Only extension cords of approved types should be used; power lines or other electric wires should be located so that if they make contact with the ground, a metal surface, or each other, causing an arc, there will be no danger of their igniting an inflammable substance.

Fuses, electric-light bulbs, drop-cord attachments, and similar devices should not be changed, plugged in, or adjusted with power in the circuit or a load on the line, if they are located near the source of inflammable vapors or gas.

Unapproved or nonpermissible flashlights or hand lamps, lighted matches, or cigarettes, or other open flames are dangerous near a source of inflammable vapor or gas.

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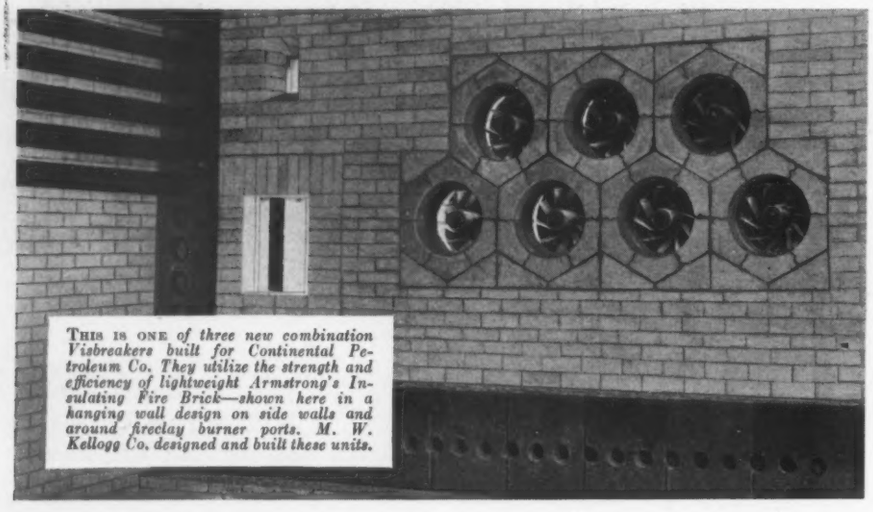
increase cracking efficiency



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Program of National Petroleum Association

Subjects that fit into the national defense program are foremost on the advance program for the thirty-ninth annual meeting of the National Petroleum Association, Traymore Hotel, Atlantic City, September 17, 18, 19. General program subjects will be heard in afternoons of the first and last days, while the group program will be restricted to morning sessions. Social functions include the fellowship supper the evening of the second day and the seaview breakfast the morning of the last day.

Harold L. Ickes, petroleum coordinator, is scheduled for the general session September 17. In case he is unable to attend, the association will hear Ralph K. Davies, assistant to the coordinator. The advance program follows:

September 17

President's address, N. H. Weber, president, National Petroleum Association.

Appointment of committees.

National Defense Chemicals from Petrolem, Dr. Gustav Egloff, Universal Oil Products Company.

Address, Harold L. Ickes.

September 18

War Conscious Washington, Paul Wooten, Washington Correspondent, McGraw-Hill Publishing Company.

Business Regulation in Britain, Lord Marley.

Group Meetings, September 17

A.P.I. Lubrication Committee, L. C. Welch, chairman.

Department of Fire and Accident Prevention, Harry S. Elkins, chairman.

Meeting of the executive committee.

Group Meetings, September 18

Department of Manufacture, M. C. Mallon, presiding.

Address, Wright W. Gary, Director of Refining of the Office of the Petroleum Coordinator.

Department of Taxation, J. E. Keller, presiding.

1941 Revenue Act, Ellsworth Alford.

Department of Traffic and Transportation, Harry S. Elkins, presiding.

Address, H. A. Gilbert, Director of Transportation, Office of the Petroleum Coordinator.

Midgley Gets Priestly Medal at ACS Meeting

Dr. Thomas Midgley, Jr., vice president of Ethyl Gasoline Corporation, was awarded the Priestly medal, highest award of the American Chemical Society, at the opening session of its annual meeting in Atlantic City, September 8. Among his achievements in chemical science is the discovery of tetraethyl lead as a non-detonating agent for motor fuel.

Since September, 1940, Midgley has been a victim of infantile paralysis. Despite this, however, he participated in proceedings of the meeting at Atlantic City. He is chairman of the board of directors of the society.

Professor William Lloyd Evans of Ohio State University, president of the American Chemical Society, made the presentation. In an address accepting the medal, given once every three years, Midgley gave a demonstration of spectacular industrial developments arising from research with which he has been associated during the past 20 years.

The Look Box

THOMAS MIDGLEY, JR.

By means of an actual gasoline engine, chemical apparatus, motion pictures, and slides, Midgley demonstrated the effect of anti-knock material in a running engine; the non-toxic, non-inflammable properties of certain organic fluorides largely responsible for a great portion of the air-conditioning industry; the experiments through which he and his associates discovered that rubber containing oxygen could be vulcanized by the addition of Grignard reagents; and the process of commercially extracting bromine from sea water.

His discovery in 1922 of tetra-ethyl lead as an anti-knock agent was made after he and his colleagues in General Motors Research Laboratories had tried more than 33,000 different chemical compounds without success. Midgley, born in Beaver Falls, Pennsylvania, in 1889, is a graduate of Cornell University. He holds the Nichols Medal of the Society's New York Section, and the Perkin Medal of the Society of Chemical Industry. The honorary degree of doctor of science was conferred upon him by Wooster College. He is a fellow of the American Association for the Advancement of Science.

CONVENTIONS

SEPT.	
8–12	**American Chemical Society, Chalfonte-Haddon Hall, Atlantic City.**
17–19	**National Petroleum Association, Hotel Traymore, Atlantic City.**
29–30	**National Lubricating Grease Institute, Stevens Hotel, Chicago.**
OCT.	
2– 3	**West Virginia Oil & Natural Gas Association, Clarksburg.**
6– 9	**National Safety Congress, Stevens Hotel, Chicago.**
16–18	**American Institute of Mining & Metallurgical Engineers, Petroleum Division, Dallas.**
23–24	**Society of Automotive Engineers, National Fuels and Lubricants Meeting, Mayo Hotel, Tulsa.**
29–30	**American Institute of Mining and Metallurgical Engineers, Petroleum Division, Ambassador Hotel, Los Angeles.**
31	**California Natural Gasoline Association, Los Angeles.**
NOV.	
3– 5	**American Institute of Chemical Engineers, Virginia City, Virginia.**
3– 7	**American Petroleum Institute, St. Francis and Palace Hotels, San Francisco.**

Two WPRA Technical Meetings Scheduled

Two regional technical meetings for October have been scheduled by Western Petroleum Refiners Association, October 3 in the Allis Hotel, Wichita; and October 17 in the Washington-Youree Hotel, Shreveport.

Three technical papers will be presented at each meeting, two at the morning session and one in the afternoon. Subjects of timely interest will be presented by qualified speakers and open-forum discussions will follow each paper.

Programs for the two meetings are being prepared by the manufacturing committee of which J. J. Allinson, vice president of Lion Oil Refining Company, El Dorado, Arkansas, is chairman.

Keppel President of Standard of Pennsylvania

Russell N. Keppel has been elected president of Standard Oil Company of Pennsylvania. New directors of the company are H. W. Chapin and G. E. Bubar. The new president has been in the organization of Standard Oil Company of New Jersey for 21 years. His first work was at the Bayonne refinery in charge of personnel education and training. In 1924 he was shifted to the Bayway plant as personnel manager and five years later he was transferred to New York headquarters as manager of the personnel and training department.

In 1932 he shifted to the sales department, as assistant branch manager at Newark, New Jersey. Next he became sales manager for the four southern divisions with headquarters in New York. When the wholesale-retail marketing organization was established in 1933 he became assistant retail manager in 1933 and held the place until 1935 when he became regional manager for the Middle Atlantic divisions. In 1939 he became regional manager for New Jersey, Pennsylvania, Delaware, Maryland and the District of Columbia.

Bubar entered services of the company in 1907 when he joined Waters-Pierce Oil Company in Mexico. Five years later he transferred to West India Oil Company. Five years later he became business manager of International Petroleum Company, Ltd. at Talara,

Peru, after which he was with Tropical Oil Company in Columbia. He became assistant sales manager of Colonial Beacon Oil Company in 1930 and moved to New York in 1934 to become head of the construction and maintenance division. In 1936 he was placed in charge of bulk plant operations for domestic sales.

Chapin entered the oil industry in 1915 at the Sarnia plant of Imperial Oil Company. After service in the first World War he took a position with the Delaware company at Baltimore. In 1920 he became manager of refined oil and gasoline sales. He became assistant manager at Baltimore in 1926. He came to New York in 1932 as marketing assistant and in 1936 took over supervision of leases and appropriations.

Pehrson Heads Bureau's Economics Branch

Elmer W. Pehrson has been appointed chief of the economics and statistics branch of the United States Bureau of Mines. Along with the announcement R. R. Sayers, director of the bureau, said the branch would be expanded to meet increased needs of the defense agencies and to fill the need for additional statistical data on the mineral industries.

Pehrson has been acting head of the branch since the retirement of James W. Furness in May, 1940. He is a native of California and a graduate of Stanford University. After spending some time in mining work he joined the United States Bureau of Mines in 1928 after two years of service with the income tax unit of the Department of Internal Revenue.

Dr. Curtis L. Wilson New Dean at Rolla

Dr. Curtis L. Wilson has been appointed dean of the Missouri School of Mines and Metallurgy, Rolla, Missouri.

Curtis L. Wilson

For the past 20 years he has been with the Montana School of Mines and for the past 13 years was in charge of the department of metallurgy.

Dr. Wilson was born in Baltimore and was graduated from the Baltimore City College in 1916, after which he moved to Montana and was graduated from the Montana School of Mines in 1920. After a year with Anaconda Copper Company, he joined the faculty as instructor. In 1926 he went to Europe and did his graduate work in the University of Goettingen, where he received his degree of Doctor of Philosophy.

Dr. C. D. Lowry, Jr., Universal Oil Products Company, Chicago, spoke before the National Tax Association, Houston, August 22, on the subject, "Sulphur in Gasoline." He pointed out the fallacy of imposing arbitrary legal limits on permissible sulphur content of motor fuels.

Washington Roundup

After a special investigating committee of the United States Senate turned its attention to the shortage of petroleum on the East Coast in early September, plans for the building of a pipe line from East Texas to the Atlantic Coast were held up and indications were that tank-car movement of both crude oil and finished products would be adopted.

Railroad officials as well as a representative of OPM said available tank cars were sufficient to deliver 200,000 barrels of oil daily. Ralph K. Davies, deputy petroleum coordinator, told the committee the shortage is 174,000 barrels, having previously been as high as 400,000 barrels.

Testimony of some witnesses indicated that the proposal of rail movement had been before the petroleum coordinator in June and that no action had been taken until late August.

Although representatives of the industry failed to indorse tank-car movement as enthusiastically as did railroad officials, a schedule of reduced rates was worked out for submission to the Interstate Commerce Commission. Executives of several oil companies signed a pledge to give the tank car program thorough trial.

To turn to tank car movement rather than pipe-line construction as a means of moving crude oil and refined products from the Southwest to the Atlantic Seaboard came after a special investigating committee of the United States Senate began digging into the question of a shortage on the East Coast.

J. J. Pelley, president of the Association of American Railroads, told the committee that 20,000 tank cars are idle and that this equipment can deliver 200,000 barrels daily into the New York area. Ralph Budd, transportation commissioner of OPM, likewise estimated that 20,000 tank cars were available.

Pelley in effect laid responsibility for failure of earlier adoption of tank-car movement to Harold L. Ickes. When hearings were resumed September 3 Pelley said:

"In December, 1940, we were officially notified by Mr. Budd that there was a possibility of withdrawing some of the tanker fleet and he asked to have representatives attend a meeting in his office with Dr. Robert E. Wilson, to discuss the movement of petroleum by tank cars." At this meeting, the railroad representatives gave the result of a tank car survey and advised the group that the reported surplus tank cars would handle in excess of 200,000 barrels of oil daily from the producing areas to the Atlantic seaboard and that locomotives were available to move the cars.

"In May, 1941, a fact-finding committee that was named by the American Petroleum Institute looked into the tank car question and this committee confirmed the fact that 20,000 surplus tank cars were available and that this equipment would move from six to eight million barrels of oil per month from Texas to the Atlantic seaboard.

"Within the past week I have seen reports of another study made of this tank car situation. This report was made by a man selected by the tank car owners and lessees and from the results tabulated to date it is still evident that there is a surplus of some 20,000 tank cars."

No Action Taken

A copy of the report to the OPM was given the petroleum coordinator's office in June, the railroad executive said, but no action was taken until August 30, when Deputy Coordinator Davies called a meeting of transportation and oil company representatives to discuss freight rates, to be held September 4.

In view of the surveys and reports made by the carriers, Pelley said, he was "surprised" at Davies' statement before the committee August 28 that he had been unable to get information on the tank car situation from the railroads.

The major obstacle to putting all available tank cars immediately to work, he explanied, is the spread between rail and tanker rates. Within the past few weeks, 41 rate reductions have been made by the roads and 40 more are pending, but even on this basis, he said, the rail rate is about six times the tanker charge.

The oil companies, he continued, are willing to do anything "consistent with good business practice" to get adequate supplies into the eastern states, but have been deterred from taking concerted action by fear of Department of Justice anti-trust prosecutions.

However, Pelley said, action could be taken by the coordinator to make use of tank cars in such a way that no individual companies would be placed at a competitive disadvantage. If 15 percent of the oil is brought in by rail and 85 percent by tanker, an averaging of the cost would mean an increase in retail gasoline prices of only 1 to 1½ cents per gallon, he estimated.

If a plan for the use of cars is worked out, he told the committee, "solid trains of oil" could be started from the southwest producing areas to the Atlantic seaboard within a week, and within two

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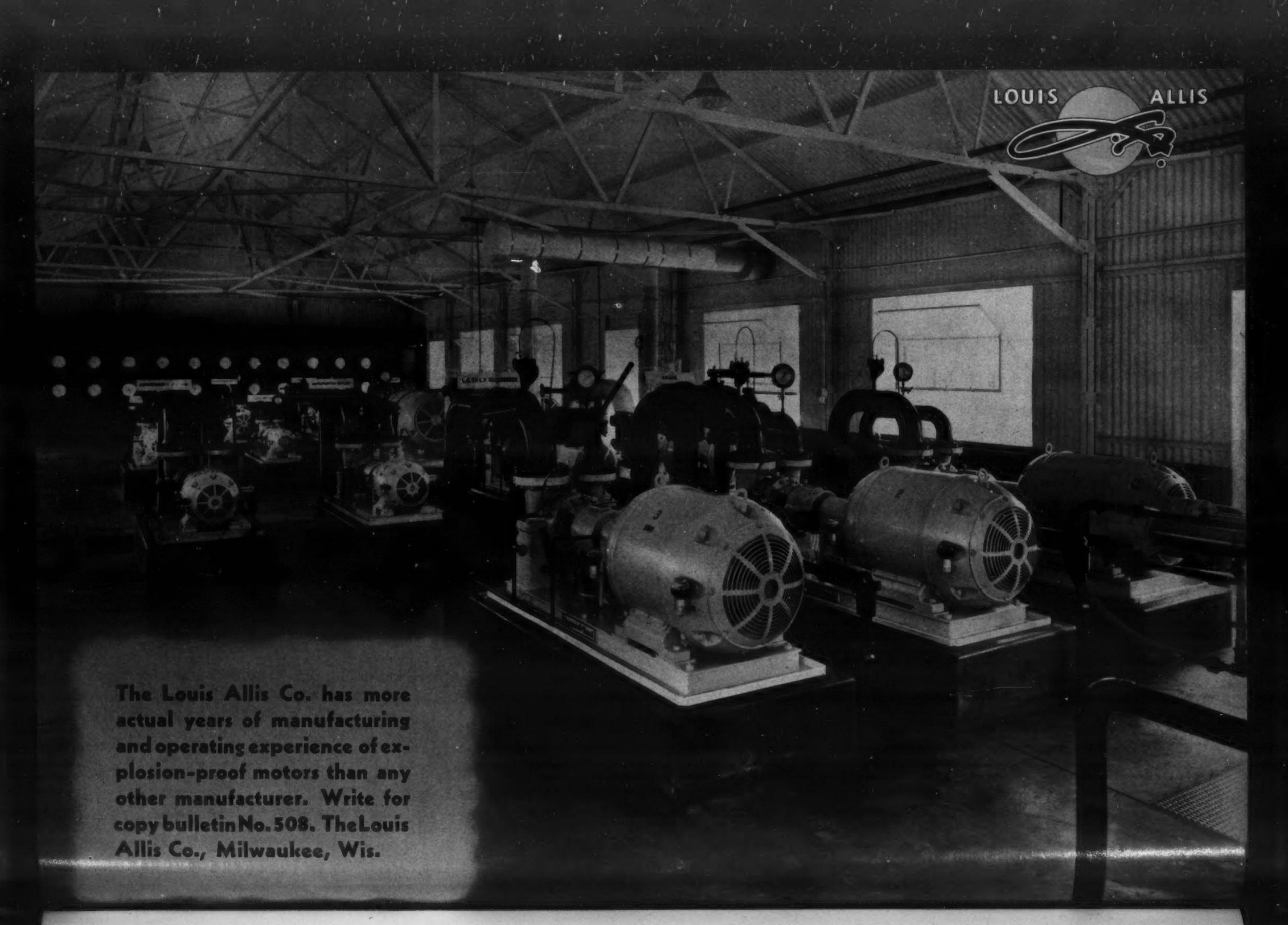
Any assistance will be appreciated.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weeks a steady delivery of 200,000 barrels or more a day could be assured.

This would more than make up the present defiiciency in deliveries, estimated by Davies at 174,000 barrels daily.

A Summary

As Pelley concluded his testimony, Chairman Francis Maloney undertook to sum up the situation.

"Mr. Davies says there is a shortage of 174,000 barrels a day," he said.

"The transportation group and the oil industry are meeting tomorrow.

"The oil people are very anxious to cooperate.

"The railroads say they are ready to go, and the equipment, engines and facilities are available or can be and will be made available.

"Whose move is it?"

Pelley replied that he thought it was the oil companies' move, but the Senator disagreed because, he said, "this shortage—or alleged shortage—originated, insofar as the public knows, in the office of the coordinator; is not it really his move?"

Gasoline Curtailment Protest

Prior to the appearance of Pelley, a written protest by Senator David I. Walsh (D., Mass.) against the cuts in gasoline deliveries was placed in the committee record.

The curtailment orders were characterized by the Senator as a "glaring example of bureaucratic blundering," and he appealed to the committee to develop some "rational" plan to meet the situation which New England industry will face this winter.

"Existing uncertainty and disputes, and the confusion as to ways and means of curtailing consumption of gasoline has created an intolerable situation that it would seem could have been avoided and most certainly needs to be remedied without delay," he declared.

Meanwhile, in an effort to speed up deliveries to the East it was reported the Interstate Commerce Commission would be asked to institute drastically lower emergency" rates on oil shipments to the coast.

The major question, however, appeared not to be the actual freight rate but the ability of the railroads to handle the long trains which would be required for a mass movement and the possession by the oil companies of adequate facilities for shipping and receiving by rail.

Rail Volume Questioned

Unless a very heavy movement can be initiated, it was indicated, the use of tank cars will have little effect on the situation, and there was some question of the ability of the railroads to sandwich in a large number of long oil trains between the heavy trains which are moving defense and civilian products.

The prospect for tank car deliveries was outlined by Commissioner Budd as follows:

"The large number of rail routes which are available make it possible to distribute the traffic load so widely that no one route or railroad would be heavily burdened.

"Last December when there were several conferences on the subject, it was pointed out that diverting oil from tanker to tank car would require loading and unloading facilities at points of origin and destination so as to load and unload cars quickly and without delay. It was understood at that time that the petroleum people would make a study of these requirements, and prepare plans and estimates of typical layouts that would be necessary and determine the length of time required to erect them. I do not know whether that was done, or the extent to which loading and unloading facilities were erected, although I do know that the unloading racks at Bayway, New Jersey, have been enlarged.

"All of the considerations which I have stated lead me to believe that it would be physically practicable for the railways to deliver 1000 carloads of oil a day to the eastern coast. Since the cars average about 200 barrels each, that would be about 200,000 barrels a day."

Henderson Favors Pipe Line

Agreeing with Chairman Maloney that you can't give pipe lines away, Leon Henderson, OPA administrator, told the Senate committee September 5 that you can't sink them, either.

Henderson took his crack at the tanker diversions after telling the committee that he favored the two southern lines now under consideration but would have to look into the question of steel supply before passing on the Texas-New Jersey line.

Going far out of his way to support Deputy Coordinator Davies, who has been under attack by the committee for failing to move faster in the development of tank car transportation. Henderson agreed with the figures of the coordinator's office on the shortage, saying that had it not been for the various expedients resorted to the deficiency

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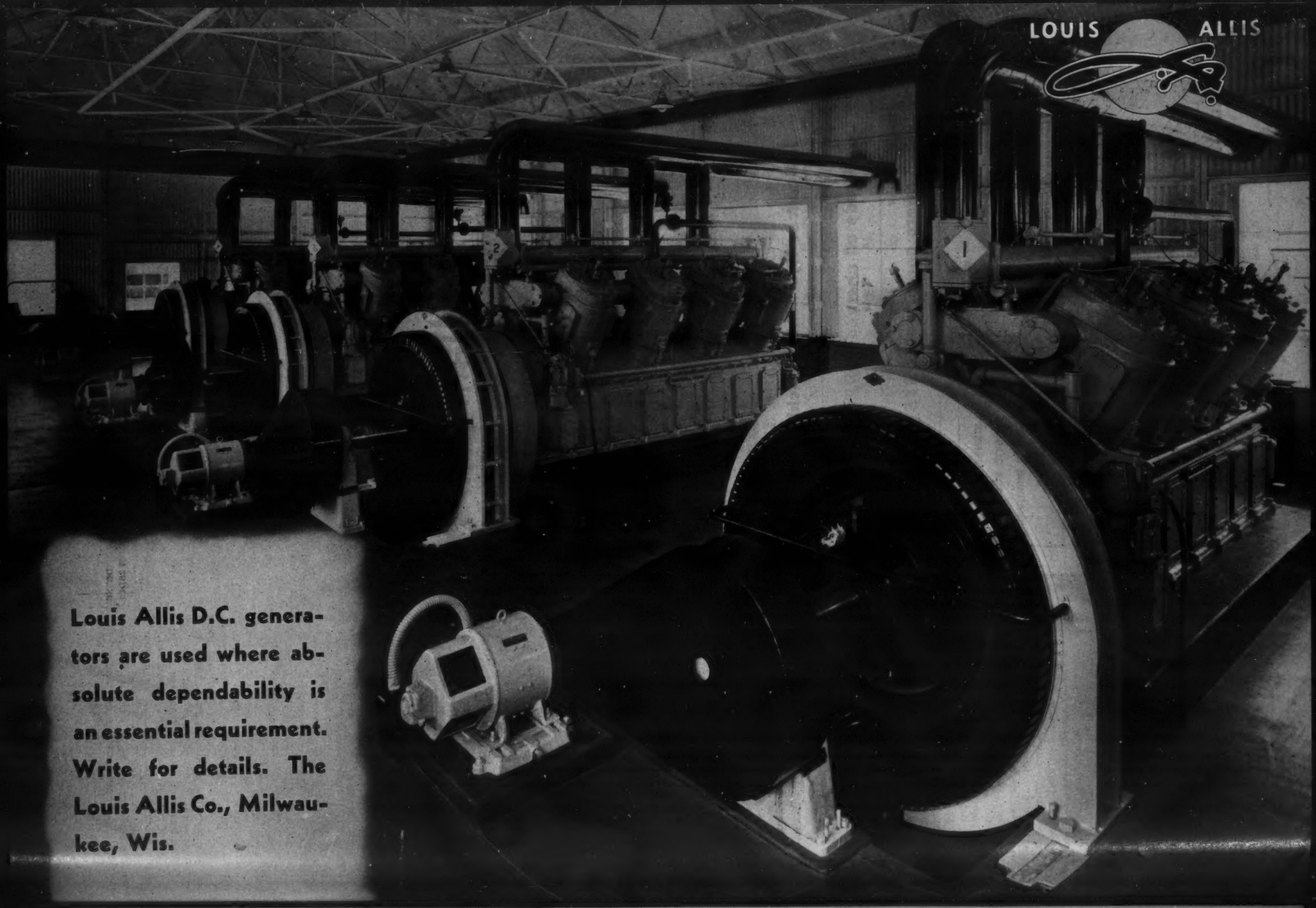
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would have been 400,000 instead of 174,000 barrels a day.

The OPA head told the committee he would be more "comfortable" if stocks on the East Coast estimated by Davies at 44,800,000 barrels by the end of this year, could be restored to their 1940-end level of 72,000,000 barrels, and disclosed that if, as promised, tank cars are able to move an additional 200,000 barrels a day into the area it is to be placed in storage as a safeguard against "potentialities."

If this is done, he said, present restrictions must be continued, but it is hoped that they can be lifted quickly. Under the present curtailment program, he asserted while deliveries are cut to 90 percent of July, that month was a peak period, and despite the cut deliveries this month will be seven percent greater than in the corresponding month last year.

Industry Reasonable

Should rationing become necessary, he commented, the OPM has full authority to impose it on fuel, power and other commodities.

The industry, generally, has adhered to its promise not to make increases in gasoline prices, he said. But added, "No one can justifiably claim that oil companies have been deterred from using higher cost transportation by considerations of price," since they have been told repeatedly that if costs actually increase there will be no objection to price increases. However, he emphasized, "The industry has been very reasonable."

Henderson said that most of the companies have a cost of about on half cent per gallon for tanker transportation, while the recently promulgated maritime commission ceiling works out to about 1½ cents in maximum and neither a minimum nor a desirable rate, and it is planned to ask for a re-examination of the rate.

While he refused to pass on the proposed long-distance pipe line, Henderson said he was in favor of pipe lines generally, as an "ace in the hole" in the event of war. Under questioning, he expressed the opinion that pipe line transportation costs were not much greater than tanker costs and raised the possibility that a 24-inch line might be able to move oil at a rate comparable to that of tankers.

Henderson declared the investigation has accomplished much in spurring the various interests to quick action to relieve the situation, and urged that the committee remain alive until the whole question has been cleared up. The OPA head was the final star witness of the week.

C. F. Dowd, traffic manager of Tide Water Associated Oil Company, New York, and chairman of the recently formed tank car subcommittee of the transportation committee for District No. 1, challenged figures of Pelley and Budd that there were 20,000 idle tank cars available.

Challenge Tank Car Figures

Dowd explained he had no personal information of the number of cars available, but questioned there were as many as represented, raising the point that even if there were cars available there was not assurance that they were of the proper type.

The tank car subcommittee, he said, intends to make its own investigation of the car situation and, he promised, as soon as it ascertains the facts, it will make a report to the Senate group.

Dowd refused to admit any personal knowledge of a shortage of oil, saying that was not within his province as a traffic man, but declared so far as his company was concerned there was no shortage of cars.

Under that schedule, rates were worked out on a schedule higher than the oil industry had sought but still satisfactory, which it has referred to the coordinator's office.

The result, he said, will be to reduce the rate on crude to New York from $2.08 per barrel to $1.37 from Longview and $1.52 from Houston; from Tulsa to New York from $2.02 to $1.27 and from Baton Rouge to Charleston from $1.55 to 93 cents. Rates from Eastern territory into the district will be reduced 50 percent. The only remaining obstacle to the prompt use of rail cars, he told the committee, will be the necessity of installing loading and unloading facilities at points of origin and destination which heretofore have operated on supplies traveling by tanker or pipe line.

Expressing "disappointment" with Dowd's refusal to give unqualified support to claims of Pelley and Budd that the railroads quickly could clear up the shortage, Chairman Maloney said "I supposed, a day or two ago, that this oil shortage was over" and had hoped the investigation could be closed. Instead, he said, it now appears probable the committee will have to call representatives of the companies into study the situation further.

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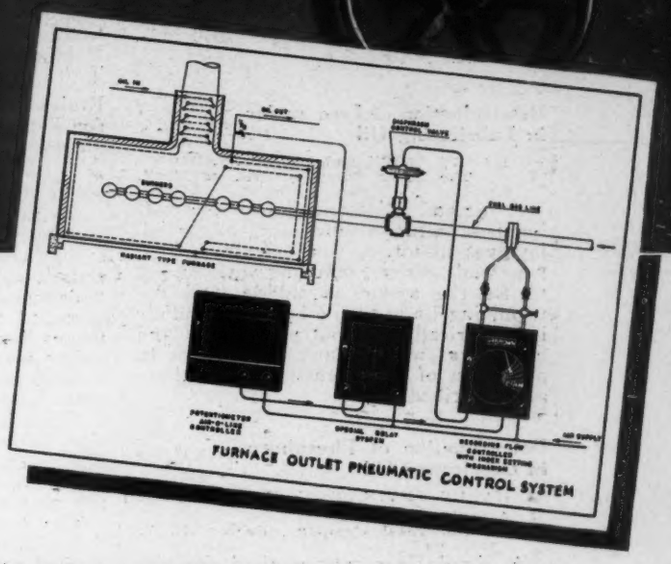

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Division of Petroleum Chemistry Of the American Chemical Society

Abstracts of Papers Presented at Atlantic City, New Jersey, September 8 to 12, 1941

Determination of Inorganic Salts in Crude Oil

E. P. RITTERSHAUSEN and R. J. DeGRAY
General Laboratories, Socony-Vacuum Oil Company, Inc.

The tetraethyl lead extraction apparatus is used to extract the inorganic salts with water. The water extract is titrated for chloride content in conventional manner. The method offers no saving in time for one sample, but with a battery of three extractors the average time per sample is less than that needed for previous methods. Duplicate determinations by one operator check to within 2 lbs. of NaCl per 1000 bbls. of crude.

Determination of Free Sulfur in Lubricating Oil

HARRY LEVIN and ERVIN STEHR
The Texas Company, Beacon, N. Y.

A method is described for determining free sulfur in lubricating oil, which involves dissolving the sample in benzone and acetone, refluxing with copper to fix the sulfur as sulfide, and determining its available hydrogen sulfide iodometrically. Special precautions and apparatus were found necessary to avoid loss of hydrogen sulfide and these are described.

Determination of Phosphorus in Lubricating Oil

HARRY LEVIN, F. F. FARRELL and A. J. MILLENDORF
The Texas Company, Beacon, N. Y.

A simple, accurate method for determining organically combined phosphorous in lubricating oil is described. It involves ignition of the sample with sodium naphthanate which serves to bind the phosphorus in inorganic water-soluble form. The water solution of the phosphate is reacted to form ammonium phosphomolybdate which is centrifuged and the phosphorus calculated from the volume of precipitate.

Determination of Mixed Aniline Points of Hydrocarbon Solvents

B. H. SHOEMAKER and J. A. BOLT
Standard Oil Company (Indiana), Whiting, Ind.

The mixed aniline point is a convenient and simple test method for evaluating the solvent properties of petroleum high-solvency naphthas. The definition of the diluent used in determining the mixed aniline point includes any naphtha whose aniline point is 60° C. Data are presented to show that widely different results are obtained in the determination of mixed aniline points of various grades of high-solvency naphthas and of C. P. toluene when using two diluents of different boiling ranges with aniline numbers of 60° C. The definition of the diluent is too broad and it is suggested that the diluent used be identified not only by its aniline point but also by its mixed aniline point with C. P. toluene.

Determination of the Aniline Point of Dark Petroleum Oils

BRUCE B. CARR and M. S. AGRUSS
The Pure Oil Company

An inexpensive apparatus is described for determining the aniline point of oils darker than 8 ASTM color. The method developed is based on the visual observation of a thin film formed on the glass wall of the apparatus. Temperatures are obtained by means of a triple junction copper-constantan thermocouple cemented to the inner wall of the apparatus and either a millovoltmeter or potentiometer is used which is calibrated to 0.1 millivolt in the range 0 to 15 millivolts. An accuracy of ±0.5° F. in aniline point can be easily attained if the apparatus is carefully calibrated.

Evaluation of Granular Adsorbents for Petroleum Refining

OGDEN FITZSIMONS
Barrett Co., and
R. C. AMERO and R. G. CAPELL
Floridin Company

No satisfactory relationship has ever been established between the decolorizing power and the composition of the fuller's earth and bauxite type of petroleum absorbents, and consequently chemical analysis is of no value as a means for control. The evaluation requires actual percolation procedures on a small scale which duplicate on a small scale larger operations in the refinery.

Controlling variables, such as particle size, activating time and temperature, bed depth, percolating temperatures and so forth, have been investigated and are reported upon.

The treating equipment and procedures based on the investigation are described and data are presented to show that the method is accurate to 3 parts in 100.

A Simple Viscometer for Research and Control

FRANK C. CROXTON
Battelle Memorial Institute, Columbus, Ohio

The increasing importance of accurately determined viscosities of petroleum products is causing widespread adoption of capillary-tube viscometers in the industry. This paper describes a viscometer which was designed to bring together practically all of the advantages of the various earlier instruments. A vapor thermostat is equipped with an interchangeable ground joint, so that any of a series of Zeitfuchs-type viscometer parts may be used therein. An equation for calculating the capillary size necessary to approximate a desired viscometer constant is given. The more important features of the instrument are its accuracy, flexibility, and speed in combination with low cost.

Naphthene Ring Analysis

M. R. LIPKIN and S. S. KURTZ, JR.
Sun Oil Company, Marcus Hook, Pa.

It is shown that the percent naphthene rings and percent paraffins plus paraffin side chains can be calculated on the basis of molecular weight and density or density coefficient and density with greater accuracy than on the basis of the specific refraction chart used by Waterman. There are fewer assumptions involved in the molecular weight density calculation than in the specific refraction calculation. The method is good throughout the range of molecular weights for which data are available and can be used for cuts of wide boiling range. Naphthene ring analysis of 143 naphthenes of one to four rings per molecule and ranging from cyclopropane to cyclooctane type rings shows an average deviation of 7 percent.

Determination of the Solubilities of Gases at High Temperatures and High Pressure by the Rotating Bomb. Determination of Critical Temperatures by the Rotating Bomb

V. N. IPATIEFF and G. S. MONROE
Research Laboratories, Universal Oil Products Co.

Within the last decade a number of investigators have determined the solubilities of nominally gaseous hydrocarbons in liquid hydrocarbons. Although the data obtained extended to relatively high pressures, the temperatures of the determinations seldom exceed 120° C. This paper outlines a method for determining solubilities at high pressures and at high temperatures by means of a modified rotating bomb. The results obtained by the method are given for the solubilities of methane and propane in benzene. The solubility of sulfur dioxide in benzene at 26° C. over a pressure range of 1.20 to 2.65 atmospheres (abs.), determined by the same method, is also included.

A study of the pressure-temperature relationship of pure substances was made using the same type of bomb. Points of discontinuity appeared on the pressure-temperature curves in the region of the critical temperature. The pressure-temperature curves of two component systems also exhibited similar points of discontinuity. This suggests a method for determining critical temperatures.

Apparatus and Methods for Precise Fractional Distillation Analysis. VI. Theoretical Investigation of Low-Temperature Fractional Analysis

WALTER J. PODBIELNIAK
Podbielniak Centrifugal Super-Contactor Co., Chicago, Ill.

A sound basis for design and choice of apparatus elements and for working out fully detailed maximum efficiency analytical procedures.

Considering low-temperature fractional analysis as essentially a constant product purity variable reflux ratio batch-distillation process, a complete theoretical investigation has been made on the minimum plate and minimum reflux ratio requirements for hydrocarbon separations of most practical interest as in the analysis of natural and cracked refinery gases and cracked C_4 fraction.

The basic charts are plots of computed minimum plates and of minimum reflux ratios against both "alpha" and top and bottom column concentrations, a list of "alphas" for the usual hydrocarbon separations of interest and a chart of effect of higher-boiling component impurity on rise of temperature on plateaus. A final derived chart plots (a) computed ideal distillation rate curves, (b) minimum plate and (c) maximum distillate rate curves for three typical hydrocarbon mixtures, including (4) integrally derived total distillation time curves.

The Problem of the Holdup Effect in Batch Fractionation

ARTHUR ROSE, C. R. BAILEY and L. L. BERTRAM
The Pennsylvania State College

The previously published general equation for batch fractionation is used to determine the types of experimental data required before significant conclusions as to the effect of holdup can be reached. A detailed example of the use of the general equation by graphical methods brings out the importance of careful experimental work on the variation of both holdup and H.E.T.P. with (1) distance from the base of a column, (2) vapor velocity, (3) still composition, as well as variation of H.E.T.P. with holdup. If experimental work shows that these variations are relatively small, the effect of holdup can be simply predicted, but this is not the case if any of the variations are large. The possibility of increasing holdup to obtain sharper separation is examined and it is concluded that this is theoretically possible, but unlikely in practice.

The Absolute Viscosity of Cis- and Trans-Decahydro-Naphthalene

WM. F. SEYER and JOHN D. LESLIE
University of British Columbia

The viscosity values given previously were merely relative, whereas the present values are in absolute units and have been determined with considerable accuracy. The difference between the two values is in no case greater than 4 percent and for the most part is less than 2 percent.

When $\log \eta$ is plotted against $\frac{1}{T}$ curves deviating considerably from straight lines are obtained. The trans form seems to behave uniformly with respect to temperature, but the cis form shows some irregularity, particularly from 110° up to 180° C. This is in accordance with other measurements carried out in this laboratory.

The Molecular Volume of Liquid Alkanes at Corresponding Temperatures

GUSTAV EGLOFF and ROBERT C. KUDER
Universal Oil Products Company
Research Laboratories, Chicago, Ill.

The comparison of the molecular volume of hydrocarbons at their boiling points or melting points suffers from the fact that these temperatures are not exactly constant fractions of the critical temperatures. When the normal alkanes are compared at exactly corresponding temperatures between their melting points and boiling points it is found that the molecular volume is an additive function with no complications from the the alternating factor. In the equation $\bar{V} = \bar{a} + \bar{b}n$ (where $\bar{V}$ represents the molecular volume and $\bar{n}$ the number of carbon atoms in the molecule) $\bar{a}$ is a linear function, and $\bar{b}$ a parabolic function, of the reduced temperature. A resulting practical application is the prediction of the density of butane below its boiling point.

Isolation of 1,2,3,4-Tetramethylbenzene, 5,6,7,8-Tetrahydronaphthalene, 1-Methyl-5,6,7,8-Tetrahydronaphthalene, and 2-Methyl-5,6,7,8-Tetrahydronaphthalene from Petroleum

B. J. MAIR and A. J. STREIFF
American Petroleum Institute Research, August 6,
National Bureau of Standards,
Washington, D. C.

The four aromatic hydrocarbons, 1,2,3,4-tetramethylbenzene, 5,6,7,8-tetrahydronaphthalene, 1-methyl-5,6,7,8-tetrahydronaphthalene, and 2-methyl-5,6,7,8-tetrahydronaphthalene, have been isolated from the kerosene fraction of petroleum by azeotropic distillation and fractional crystallization. "Best" lots of each of these four hydrocarbons from petroleum were prepared and synthetic samples of three of them were purified for purposes of identification and determination of properties. Accurate values for the poiling point, freezing point, density and refractive index for the C, D, and F lines extrapolated to zero impurity were determined for these four hydrocarbons.

Laboratory Evaluation of Some Factors Causing Lubricating Oil Deterioration in Engines

R. E. BURK, E. C. HUGHES, W. E. SCOVILL and J. D. BARTELSON
Standard Oil Company of Ohio

A new laboratory method for evaluating the deterioration of lubricating oils is described. The design is based upon a quantitative adjustment to the oil volume of the important factors influencing oil deterioration in engines. An arrangement provides a scrubbing action on catalytic surfaces induced only by the air used for aeration. The effects of these factors and of test

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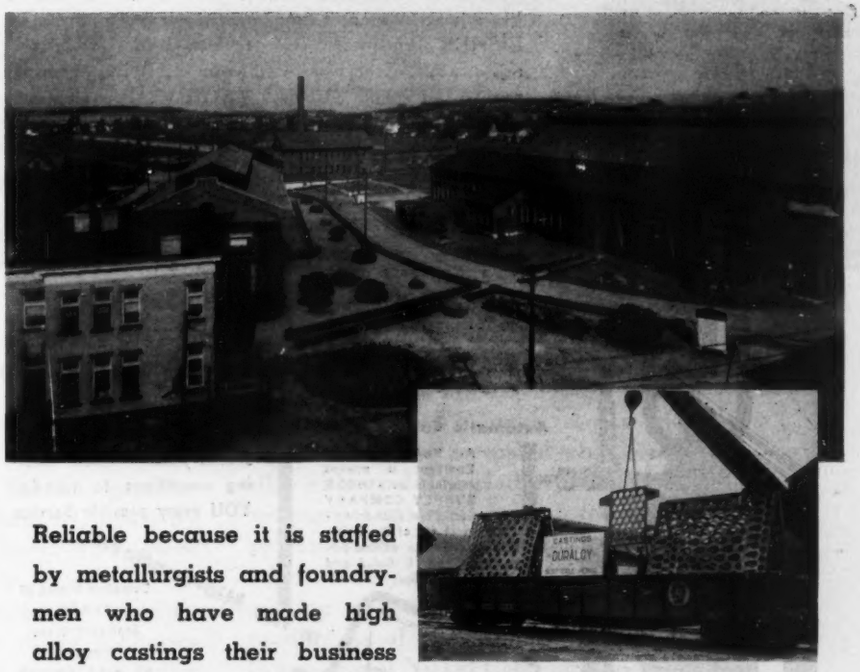

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variables are examined. The results are shown for a number of known types of oils. The correlation of such results with engines and the evaluation of detergency and bearing corrosion by this procedure are described.

Oxidation Characteristics of Pure Hydrocarbons

R. G. LARSEN, R. E. THORPE and F. A. ARMFIELD
Shell Development Company, Emeryville, California

From a study of the oxidation characteristics of pure hydrocarbons, useful information has been obtained relative to the effects of structural factors upon oxidation stability. Thus it was found that all saturated hydrocarbons, paraffinic or cyclo paraffinic, behave similarly and are quite reactive. The aromatics containing a benzene ring attached to a saturated side chain or hydroaromatic ring are still more reactive, due to the activating influence of the aromatic ring. In contrast, naphthalene and other polynuclear aromatics are very stable, apparently as a result of the formation of effective inhibitors upon oxidation.

It is concluded that stability of a lubricating oil results not from stability of the basic hydrocarbons but from content of natural inhibitors.

A Laboratory Machine for Investigating Corrosion of Bearings

S. K. TALLEY, R. G. LARSEN and W. A. WEBB
Shell Development Company, Emeryville, California

A simple laboratory machine has been devised which simulates the essential factors leading to corrosion of bearings, and permits a study of factors which control the appearance and extent of bearing corrosion. Metallographic comparisons of the laboratory specimen with corroded engine bearings confirm that the labortaory test measures pure corrosion in the absence of mechanical breakdown incidental to operation of an engine.

Of the operating factors affecting bearing corrosion, temperature has been found to be the most important. This may be due in part to its effect upon type and extent of oil oxidation and upon the existence of protective films on the bearing surface.

Calculation of Front End Volatility of Gasoline Blends

N. B. HASKELL and D. K. BEAVON
The Texas Company, Port Arthur, Texas

The increasing complexity of light hydrocarbon processing in a modern oil refinery requires adequate methods for calculating the front end volatility of various types of gasoline blends. The Reid vapor pressure and the ASTM 10 percent point are in general use as measures of this volatility. Methods are presented for the calculation of these tests on blends of refinery gasolines with natural gasolines, butane fractions, and pentane fractions. A general relationship between the RVP and the 10 percent evaporated point is an essential part of this method, as is a correlation for the prediction of the ASTM distillation loss from the C_4 and C_5 content of the stock. Accuracy of the method is good, being on the order of ± 0.2 lb. per sq. inch RVP and $\pm 2°$ F. 10 percent point.

Composition of Catalytically Cracked Gasolines

J. R. BATES, S. S. KURTZ, JR., F. W. ROSE, JR., and I. W. MILLS
Sun Oil Company

Since the advent of commercial catalytic cracking of petroleum to produce gasoline there has been much speculation as to the reason for the high octane number of this material as a motor fuel over fuels produced by thermal cracking, and over those occurring in nature as straight-run gasolines. The work presented here shows that this is due to the presence of an overwhelming excess of isoparaffins over normal paraffins in the lower boiling portions of the gasoline and to a high content of aromatic compounds in the higher boiling fractions. The olefin content of catalytic gasolines can be varied widely, with only a secondary effect on fuel quality.

Free Energies and Equilibria of Isomerization of the Butanes, Pentanes, Hexanes, and Heptanes

FREDERICK D. ROSSINI and EDWARD J. R. PROSEN
National Bureau of Standards, Washington, D. C., and
KENNETH S. PITZER
University of California, Berkeley, Cal.

There are presented in tabular and graphical form, for the two butanes, the three pentanes, the five hexanes, and the nine heptanes, all in the ideal gaseous state, values for the following thermodynamic properties for the range 298° to 1000° K.: (a) the standard free energy of isomerization divided by the absolute temperature, $\Delta F°/T$; and (b) the relative amounts of the several isomers present at equilibrium with one another. For the two equilibria, n-butane = isobutane and n-pentane = 2 methylbutane, comparison is made of

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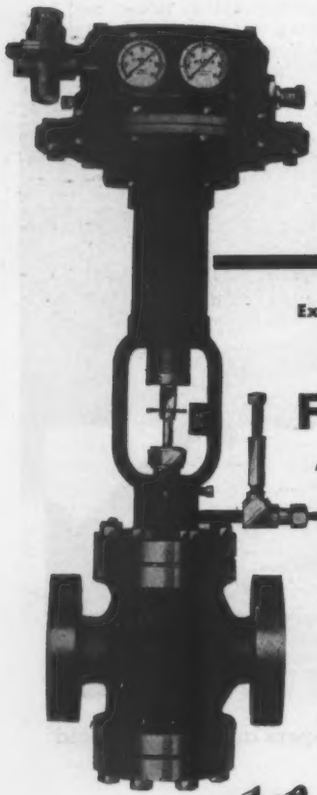

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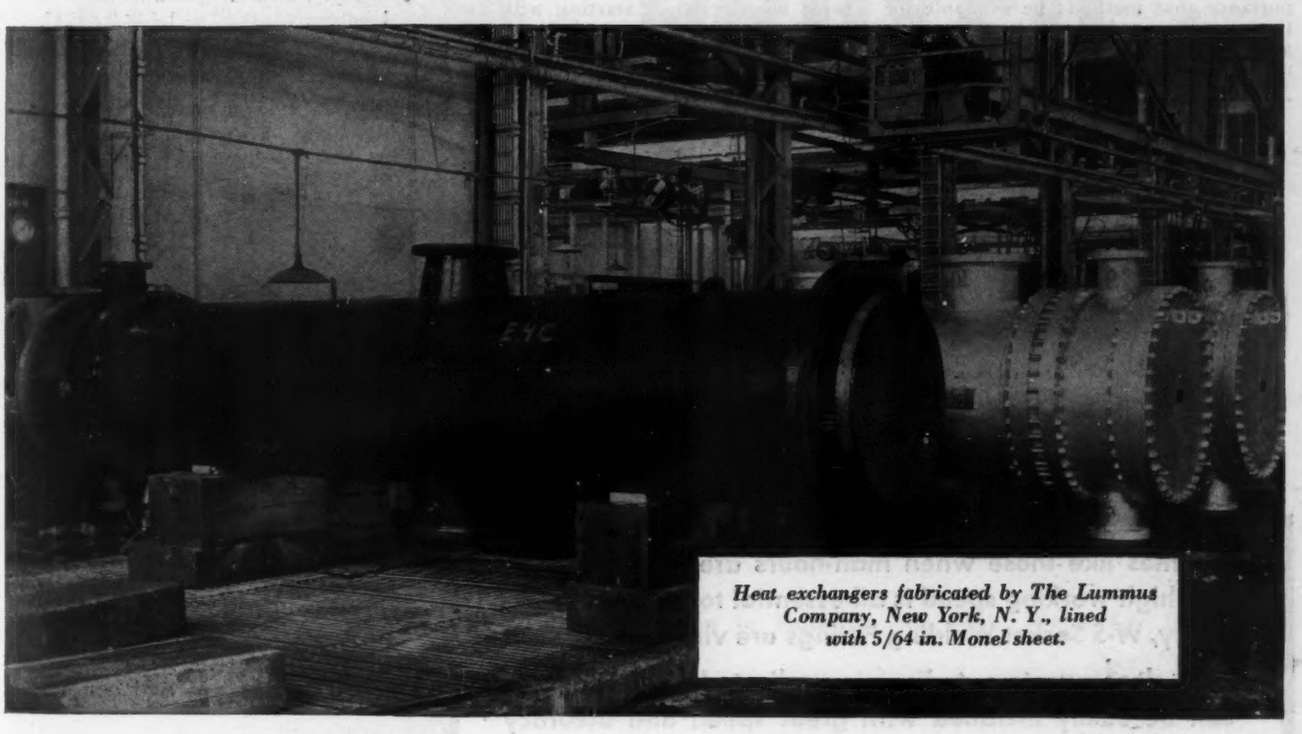

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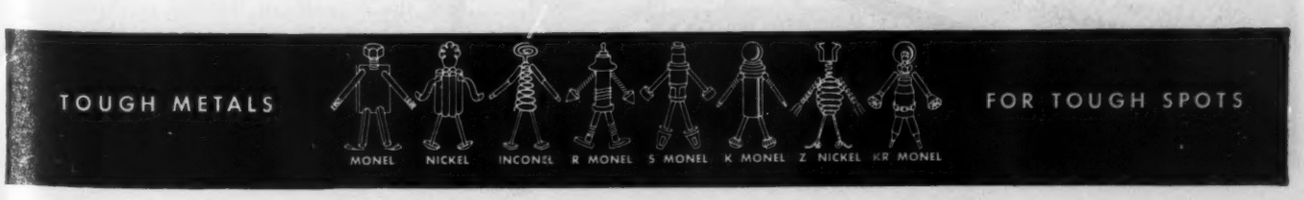


these values with the results of direct measurements of the equilibria as reported by other investigators.

The Prediction of the Octane Numbers and Lead Susceptibilities of Gasoline Blends

DuBOIS EASTMAN
The Texas Company,
Port Arthur, Texas

Most commercial gasolines are blends of a variety of structural types of hydrocarbons, to which sufficient tetraethyl lead has been added to obtain the desired octane number in the finished product. It is of great economic importance that methods be available for the prediction of the octane numbers and lead susceptibilities of such commercial blends.

Isomerization Equilibrium Among the Branched-Chain Pentenes

R. H. EWELL and P. E. HARDY
Department of Chemistry and Purdue Research Foundation,
Purdue University, Lafayette, Ind.

Twelve catalysts were studied for the isomerization of pentenes, of which activated alumina was found to be the best. None of the catalysts caused unbranching of branched-chain pentenes or branching of straight-chain pentenes. Equilibrium in the vapor phase among the three branched-chain pentenes was established at four temperatures. Equilibrium was proved by obtaining the same mixture when starting with each of the three isomers, and by the approach to a constant composition as a function of time. The analyses of the equilibrium mixtures were carried out by fractionation analysis in an electrically operated automatic fractionating column with spiral screen packing. Combination of the equilibrium constants for the isomerization reactions with the heats of isomerization calculated from Kistiakowsky's heats of hydrogenation gives the following entropy differences between the isomers:

2-methyl-1-butene(g) = 2-methyl-2-butene(g), $\Delta S^\circ = -0.64 \pm 0.05$ E.U.

3-methyl-1-butene(g) = 2-methyl-2-butene(g), $\Delta S^\circ = 0.8 \pm 0.1$ E.U.

3-methyl-1-butene(g) = 2-methyl-1-butene(g), $\Delta S^\circ = 1.4 \pm 0.2$ E.U.

High-Temperature Alkylation of Aromatic Hydrocarbons

A. N. SACHANEN and A. A. O'KELLY
Socony-Vacuum Oil Company

Aromatic hydrocarbons,—e.g., benzene and toluene—have been alkylated with olefins at high temperatures of 800° F. and above. This process was performed under atmospheric pressure and in the absence of catalysts, but high pressures and such catalysts as activated clay improved the yields of alkyl aromatics. Toluene is more easily alkylated at these temperatures than benzene. On the other hand, propylene and butylene are stronger alkylating agents than amylene. Under high temperatures the alkyl aromatics produced were partially cracked, forming alkyl aromatics of lower molecular weight. As a result, alkyl aromatics formed were composed of an entire series of aromatics beginning with toluene and increasing in molecular weight. The alkyl aromatics produced contained 90 percent or more of purely aromatic hydrocarbons.

Mechanism of Low-Temperature Catalytic Alkylation of Isoparaffins

P. D. CAESAR and A. W. FRANCIS
Socony-Vacuum Oil Co., Inc.

A simple mechanism is proposed which accounts for substantially all the observed paraffin isomers resulting from low-temperature alkylation of isoparaffins, and no others. A methyl group of the isoparaffin splits off and adds to one end of the double bond of the olefin, while the rest of the isoparaffin molecule adds to the other end.

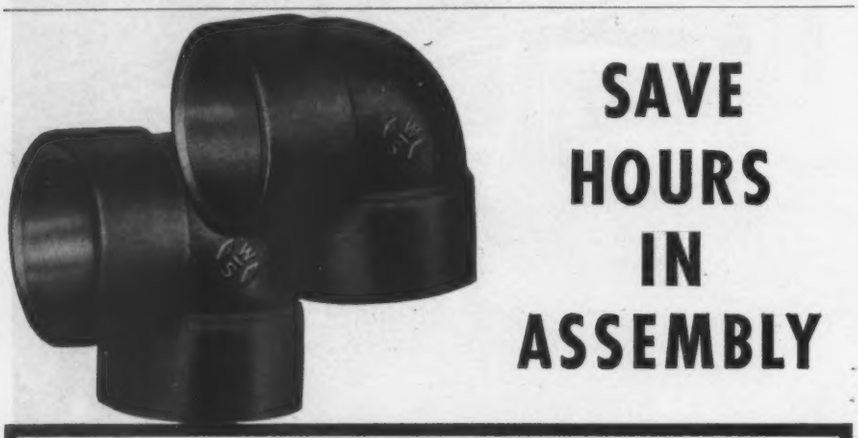
In any group of isomeric paraffins formed by alkylation, the relative amounts agree closely with those computed by thermodynamic equilibrium (excluding those not permitted by the Mechanism).

Oil Research Survey

In order to give research workers in the petroleum industry the benefit of developments in Russia, Universal Oil Products Company, 310 South Michigan, Avenue, Chicago, has instituted a weekly survey from the Russian literature. This Survey of Foreign Petroleum Literature is published weekly and contains translations and abstracts from 15 Russian journals as well as from books.

A number of oil companies are subscribing to the service, which is open to all concerns which are interested in the progress of Russian research.

This estimate of the developments in Russia was given in the announcement: "This work is being done with the discrimination that is possible only to a man who is an able chemist as well as possessing thorough knowledge of the Russian and English languages. To report a very large volume of technical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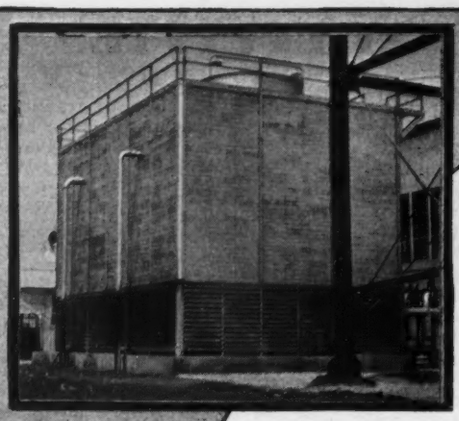

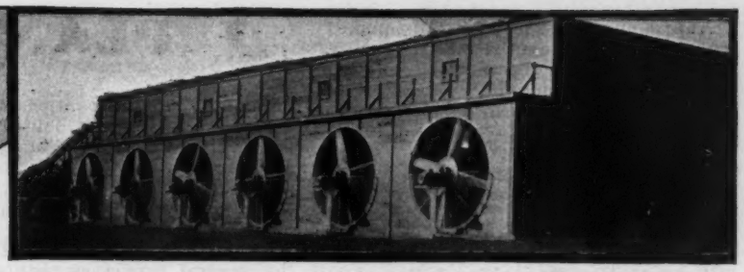

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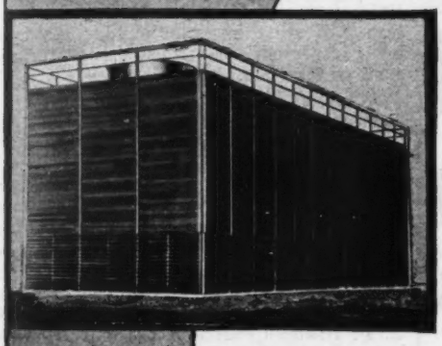

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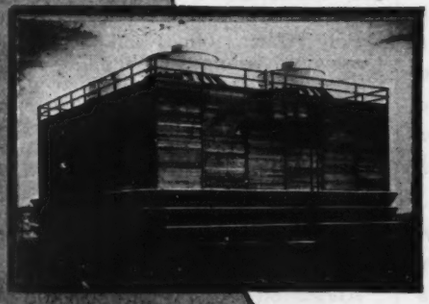

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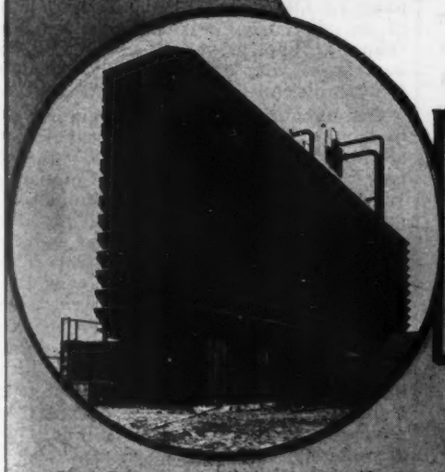

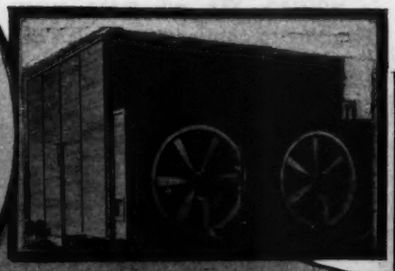

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WATER COOLING TOWERS

literature in all essential details makes it necessary to emphasize the more valuable points in the material offered, while at the same time reporting it objectively in such form as to give the readers opportunity to judge for themselves its possible usefulness to them.

"The importance attached to chemical research by the Russian government is indicated by the fact that the present Five-Year Plan of industrialization of U.S.S.R. is sometimes called the "Chemical Five-Year Plan." Russia is now considered to be the second nation in importance in chemical research, the United States being the leader. Rapid development is observed along some lines of chemical research, notably catalysis, hydrocarbons, petroleum and organic chemistry in general."

▼ PLANT ACTIVITIES ▼

Request from the office of the petroleum coordinator for doubling the output of 100-octane aviation gasoline has stimulated the necessity for refining-plant construction for 1942. While the capacity essential to this requirement is not excessive, estimated at 25,000 barrels daily, the high cost per barrel of the several processes that are capable of turning out the material call for high expenditure.

It is possible that in some areas cracking capacity may have to be expanded in order to get gases as raw material, especially for alkylation units.

The natural gasoline industry also may be called upon to fractionate butane to iso-butane as feed for alkylation. The large recycling plant recently completed at Cotton Valley, Louisiana, is equipped for iso-butane fractionation.

Prior to the end of the year the Baytown Ordnance Works, largest of the units for the manufacture of toluol from petroleum hydrocarbons, will be in operation. Another toluol plant was announced last month for East St. Louis.

Alkylation Plant: Sinclair Refining Company will build an alkylation unit at its Houston refining plant for production of material which will go into 100-octane aviation gasoline. Construction will start as soon as designs can be completed, priorities on materials assured and contracts let.

Toluene Plant: Shell Oil Company has let contract for a toluene plant at its Wood River refinery. It will have capacity of 4,000,000 gallons of toluene annually and will give the company annual production of 8,000,000 gallons of toluene, since one unit is operating at the Houston plant while another is building there.

Contracts for the Wood River unit went to the Flour Corporation and C. F. Braun Company, both of Alhambra, California. Completion is scheduled for early in 1942.

Poly Unit: Ben Franklin Refining Company, Ardmore, is building a catalytic polymerization unit, which will be operating before the end of the year. The concern is a subsidiary of Bell Oil & Gas Company, Tulsa. The unit is a U. O. P. type B., which is being constructed by Frick-Reid Supply Corporation, Tulsa. The Ardmore refining plant has crude capacity of 4500 barrels daily and a Dubbs cracking unit of 2500 barrels daily.

Alkylation Unit: Standard Oil Company of Ohio has started construction of an alkylation unit at its Cleveland refinery. The plant will produce 225 barrels of alkylate daily and is due for completion by November 1.

Gas Treating: A plant for removal of hydrogen sulfide is under construction at the Eunice, New Mexico, natural gasoline plant of Skelly Oil Company. It will handle 20,000,000 cubic feet of gas daily. The treated gas will be sold to Columbian Carbon Company, which is building a carbon black plant. The unit is the Koppers Seaboard type and is being constructed by Frick-Reid Supply Corporation, Tulsa.

Plant Sold: Brown-Strauss Corporation, Kansas City, has purchased the idle plant of Rodessa Oil & Refining Company at Cedar Grove, Louisiana, a suburb of Shreveport. Although no arrangements have been completed, it is possible that it may be put back in operation. The plant, which was rehabilitated in 1937, has capacity of 12,000 barrels daily and cracking capacity of 6000 barrels.

New Plant: The new refining plant of Rock Island Refining Company, Indianapolis, Indiana, is due to go on stream around September 15. Crude will be delivered through pipe lines from the Cement field, Oklahoma.

Plant Purchased: W. E. Anderson, president of Naph-Sol Refining Com-

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pany, Muskegon, Michigan, has purchased the 2000-barrel plant of Black Gold Refining Company at Oklahoma City. After some rehabilitation the plant will be put in operation.

Recycling Plant: Shell Oil Company has made application to the Texas Railroad Commission for the construction of a recycling plant for the Chapel Hill distillate field, Smith County, Texas. Hunt Oil Company, Sinclair Prairie Oil Company and Sun Oil Company will be associated in the venture, while other owners of distillate wells may join in the construction program. Preliminary plans call for a plant capable of treating 35,000,000 cubic feet of gas daily, from which 2000 barrels of finished materials will be extracted, while dry gas will be returned to the Paluxy sand for pressure maintenance.

Bradford Plant Sold: Kendall Refining Company, Bradford, Pennsylvania, has purchased the plant, land and pipe lines of Bradford Oil Refining Company, Foster Brook, Pennsylvania. The purchase was at auction and the price was $305,500. J. B. Fisher, vice president of the purchasing company, said the transaction was "primarily in connection with the development of specialty products from Pennsylvania oil and from the standpoint of light oil storage."

On Stream: The new refining plant of Continental Oil Company, Lake Charles, Louisiana, has been put on stream after completion of test runs.

Recycling Plants: Construction work on the recycling plant of LaGloria Corporation near Falfurias in the Corpus Christi area was completed last month. It will handle 150,000,000 cubic feet of gas daily, being the largest plant yet constructed in Texas. Hudson Engineering Corporation, Houston, which in June completed a plant of identical gas throughput at Cotton Valley, Louisiana, did the construction at LaGloria.

Canadian Refinery: McColl-Frontenac Oil Company has been given priorities and other concessions required by the Canadian government for building a 3500-barrel refining plant at East Calgary. The plant will specialize in the production of aviation gasoline.

Topping Plant: Western Michigan Refineries, Inc., has started construction of a 1500-barrel topping plant at Reed City. The concern has purchased the equipment of the Glenco Refining Company, built at Bloomingdale in 1939. Rae Andres, Wyman, Michigan, president of Sweet Oil Company, is president of the new refining concern. Other officials are J. P. O'Neal, vice president; Robert W. Fish, secretary-treasurer, both of Big Rapids. F. J. McCormick, former superintendent of the Old Dutch Refining Company, Muskegon, is superintendent. The plant is due to be on stream by October 15.

Sulphur Removal: Carter Oil Company is building a pilot plant for determining methods for removal of sulphur compounds for distillate production of the McKamie field, Lafayette County, Arkansas.

Don J. Baize has resigned as superintendent of Roosevelt Oil Company, Mt. Pleasant, Michigan. Leon Martin, assistant superintendent, has been named acting manager.

R. W. Leslie Manager Wasatche Operations

Dr. R. W. Leslie is now manager of operations for Wasatche Oil Refining Company, Salt Lake City, Utah. He was in charge of research for Skelly Oil Company at its El Dorado, Kansas, plant prior to the change.

Design Handbook

From his lectures in an Industrial Engineers Training Class Dr. Alois Cibulka has compiled the "Design Handbook for Practical Engineers." It is dedicated to H. C. Wiess, president of Humble Oil & Refining Company and "intended for the busy industrial engineer, who has no time to dig through long text books." Of the compilation the author classes it as an effort to "combine the useful information now scattered in hundreds of different industrial catalogs."

The price is $10 per copy from the author at Baytown, Texas.

Early Release for Minerals Year Book

Publication of the Minerals Year Book of the United States Bureau of Mines is scheduled for printing three months earlier than in past years. The current edition will be placed on sale by the Superintendent of Documents, Washington, early in September.

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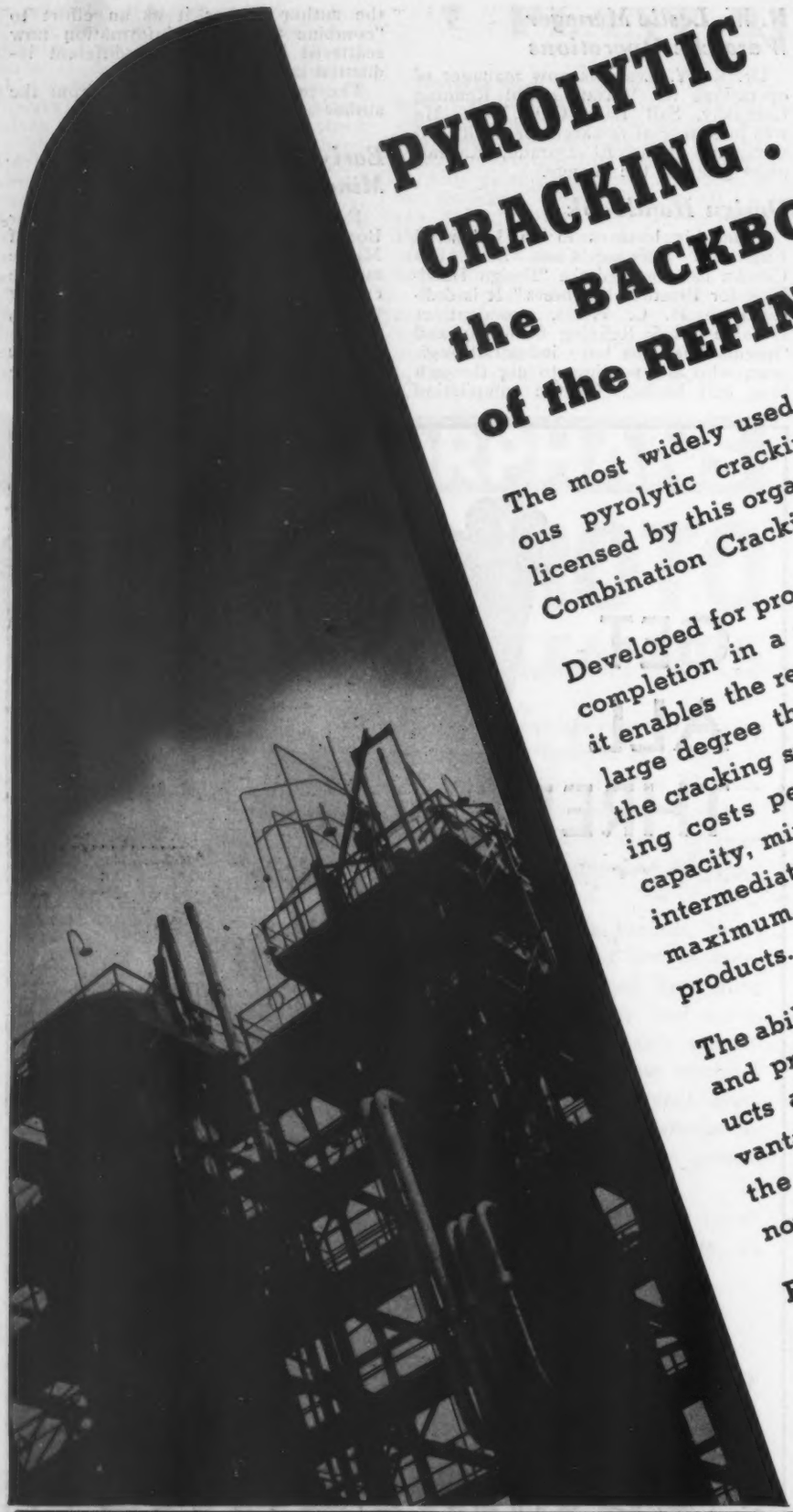

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Calculation of Partial Pressures of Binary Mixtures, R. M. LEVY, *Ind. & Eng. Chem.* **33** (1941) pp. 928-31.

In the past many equations, mostly of an empirical nature, have been suggested for the calculation of liquid-vapor equilibria of binary mixtures. The author has found a semiempirical expression which closely approximates the experimental results for various solutions. The derivation of his equation is given. Two sets of equations are included. The first applies to a wide range of solutions that do not deviate too far from the ideal solution and whose deviations are symmetrical. The second set has a much wider range of applicability, and applies to systems whose deviations from the ideal solution are greater and need not be symmetrical. The equations can be used if two special accurately determined points on the total pressure or boiling point curve are known. Tabulations of the experimental and calculated data for six systems are included in the article.

Micromethod for Identification of Volatile Liquids, S. W. BENSON, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 502-4.

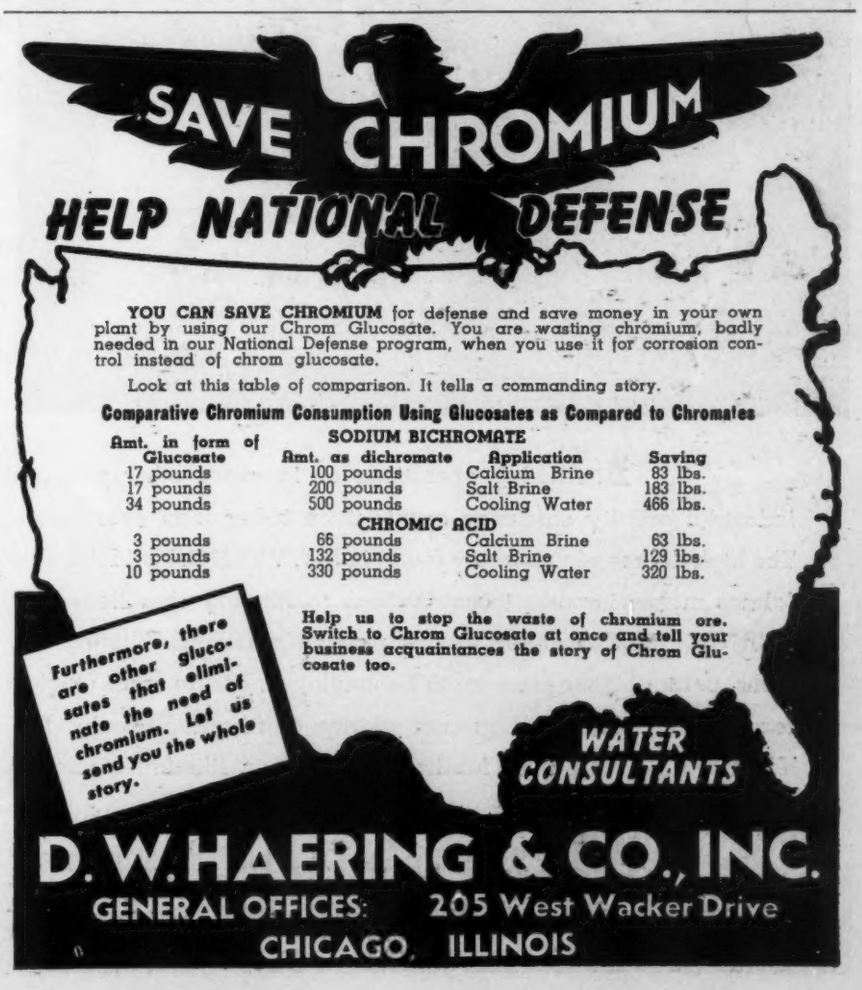
An apparatus is described for measuring the molecular weight, vapor pressure over a range of temperatures, and density of a liquid. As little as 5 mg. can be used and identified from the above properties. The method, together with the microanalytical technique of Blacet constitutes a complete system for the identification of small amounts of products in kinetic reactions. Data are given in the article for vapor pressures of cyclopentane and the pentenes. Heats of vaporization were calculated.

Computation of Some Physical Properties of Oils at High Pressures. I. Density, R. B. DOW AND C. E. FINK, *J. App. Phys.* **11** (1940) pp. 5, 353.

The density of a fluid lubricant at a pressure of p pounds per square inch gauge is given by an equation of the form $\rho = \rho_0 (1 + ap - bp^2)_t$ in which ρ is the density at pressure p and temperature t, ρ_0 the corresponding density at atmospheric pressure. The constants a and b are evaluated within the temperature range 20 to 220°F. The equation is found to hold up to pressures of 50,000 pounds/square inch. Although the equation was derived for mineral oils, it also holds for fish, animal, and vegetable oils.

Mixed Solvent Extraction, A. V. BRANCKER, T. G. HUNTER AND A. W. NASH, *Ind. & Eng. Chem.* **33** (1941) pp. 880-84.

Within the last several years considerable development has occurred in the refining of oils by use of mixed solvents of two or more components. Of the many interesting solvent combinations possible, the simplest appears to be the case in which the two solvents are completely miscible and, in addition, one of the solvents is partially miscible and the other wholly miscible with the oil. In the belief that a study of such a system would be helpful in the proper understanding of double solvent refining processes, the equilibrium in the four-component system acetone-acetic acid-chloroform-water was studied at 25°C. At this temperature chloroform and acetone were completely miscible. Water, corresponding to the principal solvent, was partially miscible with chloroform and completely miscible with acetone, while acetic acid, corresponding to the auxiliary solvent, was wholly miscible with chloroform, acetone, and water. The study of this system was followed by the investigation of equilibrium, at the same temperature, in the system lubricating oil- acetic acid-chloroform, where the oil and the principal solvent acetic acid are partially miscible, the oil and the auxiliary solvent chloroform are wholly miscible, and the two solvents are entirely miscible. These systems were chosen, not for their industrial importance, but rather for convenience of analysis in terms of the individual components. The space representation of the equilibria in the four-component system is considered on the basis of graphical representation, either based on a regular tetrahedron or on a right equilateral triangular prism. Data obtained in the work are presented and their space representation considered and discussed in some detail. It is now well established that phase equilibrium data for three-component and single solvent oil systems can be used to forecast solvent extraction results. Since it has been shown by the authors in a previous publication that phase equilibrium data for four-component and double solvent oil systems can be readily handled, the forecasting of extraction results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Calcium Brine
83 lbs.
17 pounds
200 pounds
Salt Brine
183 lbs.
34 pounds
500 pounds
Cooling Water
466 lbs.
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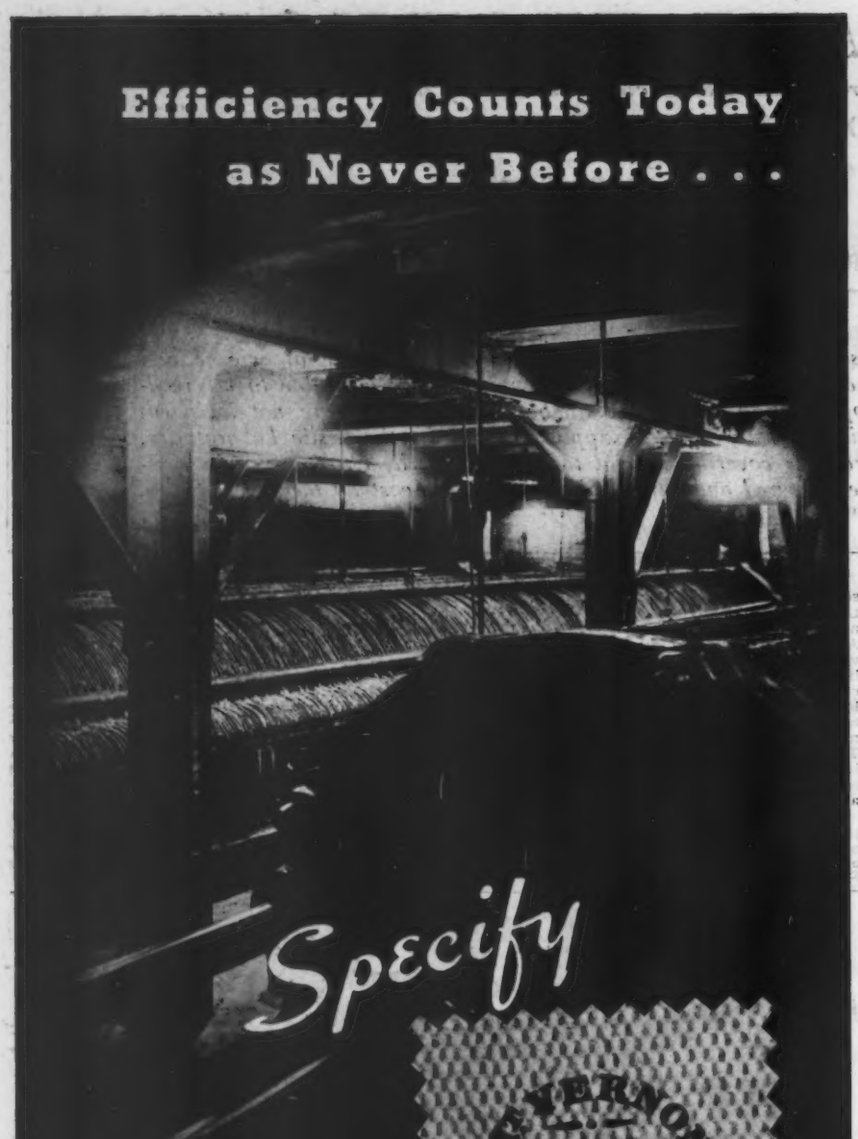

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Chemical Compositions and Reactions

Alkyl Substituted Hexaarylethanes. XI. Symmetry and Steric Effects as Factors in Dissociation, C. S. MARVEL, J. F. KAPLAN AND C. M. HIMEL, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 1892-6.

Several mono-, di- and trialkyl substituted triarylcarbonols were prepared and converted to the corresponding chloromethanes, hexaarylethanes and triarylmethyl peroxides. Magnetic susceptibility measurements were made on the ethanes and from these measurements the per cent dissociations of the ethanes were calculated. The results show that (a) ortho-alkyl substitution greatly increases the degree of dissociation of a hexaarylethane, (b) meta-alkyl groups are more effective in promoting dissociation than para-alkyl groups, (c) next to the ortho-effect, symmetry of the ethane seems to be the most important factor in promoting dissociation.

Catalytic Polymerization of Ethylene under Ordinary Pressure, Y. KONAKA, *J. Soc. Chem. Ind.,* Japan **43** (1940) p. 363B.

The investigation reported is a continuation of researches on the polymerization of methane, in which the author studied the effect of hydrogen and nitrogen on the formation of polymeric products. The use of hydrogen with methane resulted in lower yields of polymer oil than with methane alone, and the amount of oil varies inversely with the amount of hydrogen. Nitrogen has no effect on the polymerization of methane other than acting as a diluent. The role of the CH_3 group in the course of the formation of the oil was also studied. The yield of oil was poor from CH_3 alone, and catalytic activity was quickly destroyed. $CH_3 - H_2$ mixture in the proportion 1:1 gave the maximum yield of polymer oil and the longest catalytic life. The polymer oil so formed was composed largely of aromatic and olefinic hydrocarbons, and the greater part of the oil distilled above 100°C. This is in marked contrast to the oils obtained from CH_4 only, as this oil was found to be composed largely of paraffinic hydrocarbons and distilled largely below 100°C. The oil obtained from CH_3, CH_4, and H_2 mixture differed definitely from the oil from CH_4 alone; that from the mixture was composed largely of aromatic and olefinic hydrocarbons.

(Resinous) Polyisobutylene Compositions, L. LIGHT, *Oil Colour Trades J.* **98** (1940) p. 297.

When isobutylene is highly polymerized it resembles natural crepe rubber, but, because it lacks unsaturation, it deteriorates less on aging. References to patents covering its use in copolymerization reactions to form glass-clear resins and molding powders, in water-proofing, insulation, pigment dispersion, mustard-gas proofing, and the like, are given.

Manufacture: Processes and Plant

Heat Transfer by Organic Fluids, M. H. LEWIS AND D. W. RUDORFF, *Engineering* **151** (1941) pp. 261-4.

Data on the heat-transfer characteristics of biphenyl and some other organic compounds are given. Dowtherm A has proved useful in general industrial practice. It is a mixture of 73.5% diphenyl oxide and 26.5% biphenyl. It remains liquid at 12°C. and contracts slightly when solidifying. The boiling point at atmospheric pressure is 260°C.; at 315°C. the saturated pressure is 30 pounds per square inch, and at 400°C. it is 150 pounds per square inch. The upper working temperature limit for this and other biphenyl compounds is possibly 400°C., for at higher temperatures the compounds decompose slowly. Data are given on operating units using liquid-phase and vapor-phase heating media.

Plate Efficiency Study in Ethyl Alcohol Distillation, L. BYMAN AND D. B. KEYES, *Chem. & Met. Engr.* **48** (1941) pp. 85-7.

The purpose of the investigation was to determine the effect of several factors on plate efficiences of a fractionating column. The system ethyl alcohol-water was used in the study because the equilibrium diagram is fairly accurately known. The column used had four plates. Samples of both liquids and vapors were taken. It was found that vapor velocity had no appreciable effect on plate efficiency except at very low distillation rates, which gave somewhat higher efficiencies than at moderate vapor velocities. Rather

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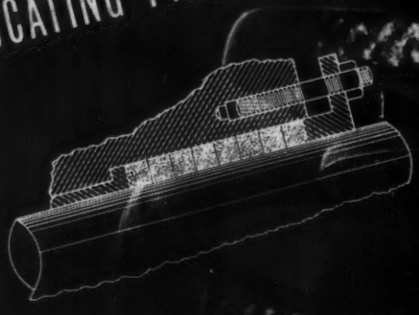

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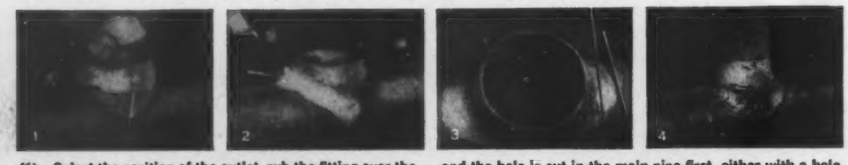

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marked changes in reflux ratio had little effect on plate efficiencies, although the higher ratio in general gave somewhat higher efficiencies. Plate efficiency varies with the composition of the liquid and vapor passing through the plate. Very low efficiencies were found when the concentration of ethyl alcohol was either very low or relatively high. No significant relationship was found between surface tension and plate efficiency. There is a general correspondence between viscosity at the boiling point and plate efficiency. The data are presented in graphical form. A bibliography of 20 references is given covering articles that bear on the general subject.

Electron Tubes in Petroleum Research, C. J. AND D. J. POMPEO, *Electronics* **14** (1941) No. 4, pp. 20-3; No. 5, pp. 43-6.

The application of vacuum tubes in process and product control oil-refinery work is described. Also, an electron-tube method for measuring and recording the rapidly varying pressures within the cylinder of an internal-combustion engine is described. A polished and flexible diaphragm is mounted as closely as possible to coincide with the inner surface of the cylinder head. By use of a mirror, light source and phototube variations in cylinder pressure are automatically recorded by a beam on the fluorescent surface of a cathoderay tube. The apparatus is described in some detail.

A 60-Plate Low Holdup Laboratory Fractionating Column, A. J. BAILEY, *Ind. & Eng. Chem.,* Anal. Ed. **13** (1941) pp. 487-91.

A column that has proved itself versatile and successful in the precise analytical fractionation of small quantities of material is described. An 8 mm. inside diameter tube, 10.5 feet long, was filled with glass helices 3 mm. in diameter. The column was found to be the equivalent of 60 theoretical plates, the height equivalent to a theoretical plate being 2 inches. The holdup was less than 0.1 ml. per plate. The column was fitted with a still head for total condensation, with variable take-off. All-glass construction was used, and in general the construction was such as to be economical as well as simple. The column could be operated either at atmospheric pressure or under vacuum. Several interesting efficiencies of various types of analytical columns were determined in the course of the study of the columns at the outset of the work. A single, empty 14-mm. inside diameter tube, 5 feet long, operated under adiabatic conditions gave an H.E.P.T. of 10 inches. A concentric tube column gave an H.E.P.T. of 6.3 inches. Glass helices in a 14-mm. and in an 8-mm. tube gave an H.E.P.T. of 2 inches, and indicated that the irregular packing next to the wall is unimportant. A column packed with 7-mm. Raschig rings gave an H.E.P.T. of 4.1 inches. Brass jack chain gave 4.0 inches.

Synthetic Chemicals in Fuels and Lubricants, W. G. WHITMAN, *Ind. & Eng. Chem.* **33** (1941) pp. 865-8.

The petroleum industry is today attracting wide attention as a potential producer of raw materials for chemical synthesis. However, emphasis on petroleum as a raw material has tended to overshadow the growing utilization of synthetic chemicals in the products that the petroleum industry markets. The author's paper is intended to orient technologists of other industries as to the nature and scope of these product developments. Synthetic chemicals are used in fuels and lubricants in two ways: (1) as addition agents that are incorporated in small percentages, and (2) as blending agents that are utilized in considerable proportions and which in themselves contribute much of the fuel or lubricating value of the product. Among the addition agents discussed by the author are: antiknock agents, such as tetraethyl lead, antioxidants used in thousandths of percent of one percent to prevent the deterioration of gasoline through oxidation in storage, metal deactivators to counteract the catalytic effect of metals, particularly copper, in the oxidation of gasoline, cetane improvers such as are added to Diesel fuels to improve the ignition quality, pour point depressors such as the alkyl naphthalenes, additives to improve motor oil performance, to increase resistance to oxidation, varnish formation, ring sticking, suidge formation, corrosion, and wear, extreme-pressure lubricants containing substances that react with the metal surfaces and prevent scuffing or welding of the surfaces. Blending agents include such materials as synthetic octane of high antiknock value as made by several processes from butylene and butane. Manufacturing procedures used are briefly reviewed.

Liquid Films in the Viscous Flow Region, S. J. FRIEDMAN AND C. O. MILLER, *Ind. & Eng. Chem.* **33** (1941) pp. 885-91.

In the general field of diffusional processes, including absorption, extraction, heat transfer,

2 Recent OLIVER PRECOAT "Repeats"

A The company buying the first OLIVER PRECOAT FILTER to go into the petroleum refining industry has just ordered another—a larger unit.

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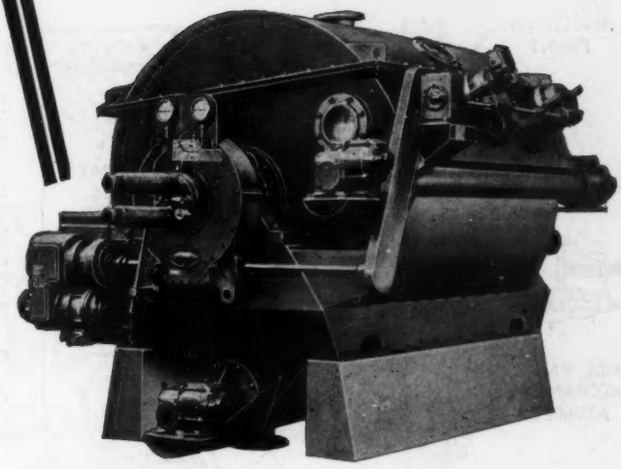

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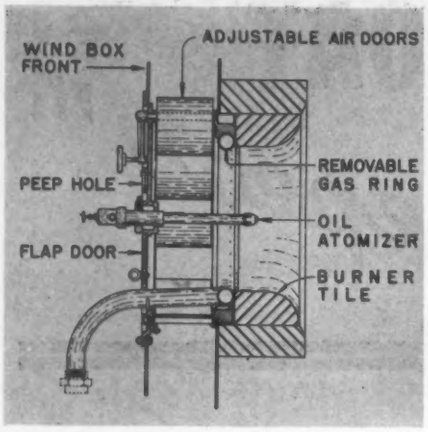

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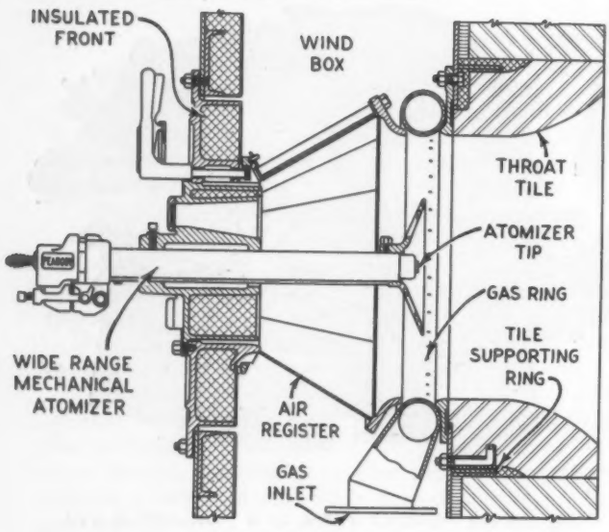

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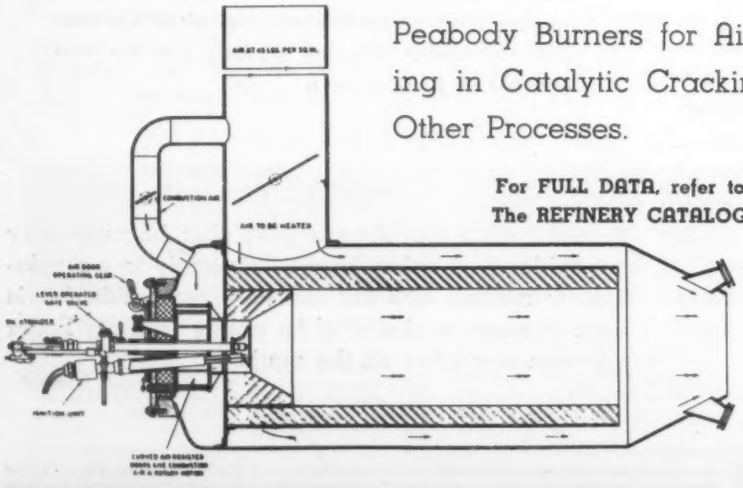

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humidification, and distillation, the flow of thin liquid films is often encountered. In the treatment of filmwise condensation or in diffusional processes, where both liquid and gas films or the liquid film alone is controlling, the flow characteristics of the film liquid have a definite bearing upon the efficiency of the operation. The more exactly the film thickness, interfacial velocity, and average velocity of the film liquid can be evaluated, the more precisely the mass transfer or heat transfer data can be analyzed. In the case of flow of liquid films bounded by solid and essentially static air interfaces, a third type of flow called "pseudo-streamline" has been found to exist between Re 25 and Re 1500. This type of flow is characterized by the appearance of waves in the liquid film and by a much higher interfacial velocity than that predicted by streamline flow equations. However, the Reynolds number-friction correlation for true streamline flow is applicable in this region. The authors discuss previous works in this general field, and than consider their own experimental work in some detail. The change from streamline to "pseudo-streamline" flow is a function of the Reynolds number, and is not a function of the diameter of the tube down which the liquid is flowing if the velocity, density, and viscosity of the surrounding medium are kept essentially constant.

Hydro-Cracking of Gas Oil, Part I, H. OTUKA AND Y. MIYAHARA, *J. Soc. Chem. Ind., Japan* **43** (1940) p. 363B.

The hydro-cracking of a Siragiku gas-oil was studied with respect to reaction temperature while using ammonium thiomolybdate as catalyst. It was found that the yield of liquid products was highest at 400° C., lowest at 550° C., and maximum at 450° C. Gasoline formed consisted mainly of naphthene, paraffin, and aromatic hydrocarbons. The hydrogen consumption was almost constant at 3-4% by weight between temperatures 400° and 500° C. At 550° C. the consumption of hydrogen was small owing to evolution of hydrogen caused by dehydrogenation reactions that occur at this temperature.

Hydro-Cracking of Gas Oil, Part II, H. OTUKA AND Y. MIYAHARA, *J. Soc. Chem. Ind.,* Japan **43** (1940) p. 454B.

The hydro-cracking of a Siragiku gas-oil was studied in the presence of a nickel catalyst. The maximum yield of gasoline was found at 450° C. as it was when using a molybdenum catalyst. In general the amount of gaseous products was larger with the nickel catalyst than with the ammonium thiomolybdate catalyst except at 400° C. The nickel catalyst was in general more destructive in its action and more sensitive to the effect of temperature than the molybdenum catalyst.

Products: Properties and Utilization

Fallacies Concerning Lubricants, W. E. GOODAY, *J. Chem.,* Met. Mining Soc. S. Africa **41** (1940) pp. 128-40.

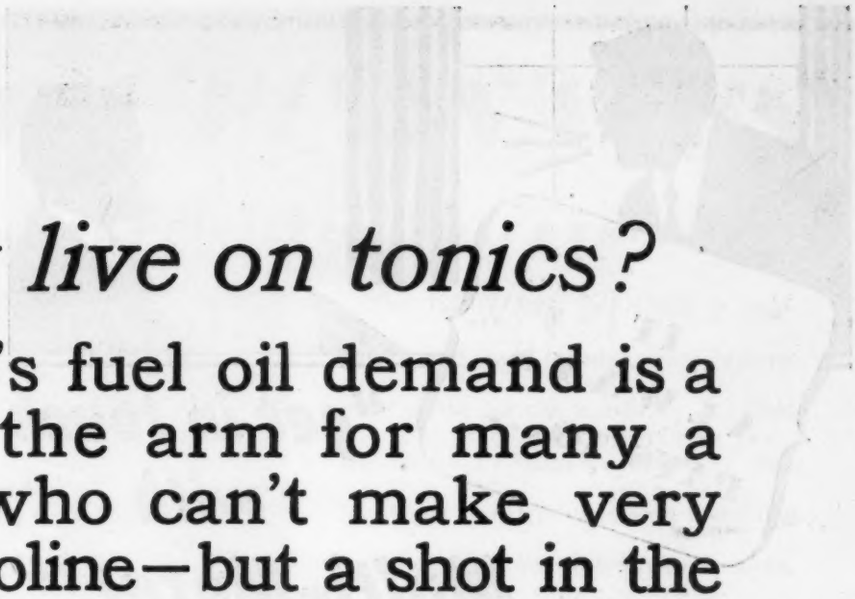
The density of a lubricating oil bears no relationship to its performance. Flash points can indicate contamination, but are not to be used to estimate comparative rates of evaporation. Color has little more than esthetic value. Viscosity is of great importance, and must be considered in relationship to the temperature conditions of service. The interpretation of acid tests is confusing. Acidity can be considered, along with other properties, as an indication of resistance to oxidation in use. Use of the term "sludge" is not consistent in practice. Compounded oils or specially treated extreme-pressure lubricants should not be mixed, because they may not be compatible.

Crankcase Oils for Heavy-Duty Service, H. R. WOLF, *S.A.E. Journal* **48** (1941) pp. 128-37T.

Crankcase oils must be stable, and must be such as to prevent deposits in the engine. These characteristics are not determined by routine laboratory inspection tests. The desired characteristics can be obtained through the use of inibitors and of detergents. The author gives oil analyses following road and dynamometer tests. These indicate that no one set of test conditions can be considered to give a complete evaluation of an oil. When metallic soaps are used as detergents corrosion of copper-lead bearings will result. These soaps may not only catalyze the formation of acidic products through oxidation of the oil, but may also break down under high pressure to yield free acids. Some other metallic detergent compounds do not have these effects.

Notes on Filtration and Distribution of Lubricating Oil, T. C. WORTH, *J. Inst. Automobile Engrs.* **9** (1940) pp. 13-32.

Solid particles from used lubricating oil are absorbed on cotton fibers as may be observed



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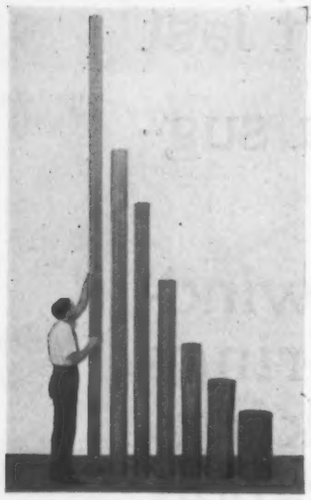

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under a microscope when the oil is passed through a filter mat held between two glass slides 0.02 inches apart. Passing an oil through an insulated filter, with a pressure drop up to 35 pounds per square inch, produces an electrostatic charge as high as 20 volts. Methods of filtration for use in connection with automotive engines are described.

Studies in Lubrication. Part VIII.—Lubrication of Plane Sliders, F. MORGAN, M. MUSKAT AND D. W. REED, *J. Appl. Phys.* **11** (1940) p. 541.

The authors experimented with lubrication in the thick-film region for fixed angle and for pivoted slides. Variations of viscosity, relative speed of sliding, and load were studied. The moving surface was made of steel, and the stationary surfaces of steel, brass, and bronze. The differences between the results of the experiment and the calculations of theory for the fixed slides were explained on the basis of inaccuracies in the sliders. The pivoted slides were found to give excellent agreement with theory.

Extreme-Pressure Addition Agents, E. A. EVANS AND J. S. ELLIOTT, *Jour. Inst. Petr.* **27** (1941) pp. 165-187.

The authors discuss extreme-pressure addition agents and note that anyone considering the subject may very well feel perplexed at the variety of materials patented. If the list is segregated, even roughly, into groups, a little more light is shed on the subject. Broadly speaking, additives may be classed as sulphur, chlorine, phosphorous, and nitrogen compounds. The sulphur compounds can be sub-divided into derivatives of mineral oils, fatty oils, organic acids, esters, polymers, and a variety of specific aliphatic and aromatic compounds. Various types of sulphur compounds that have been used are first considered and briefly discussed. Following that chlorine compounds are considered, as well as compounds of sulphur with sulphur and chlorine, compounds of phosphorous, compounds of phosphorous with sulphur or chlorine, nitrogen compounds, and some miscellaneous compounds. Experimental work is then reported. The Almen machine was used in the test. Results are reported for various hydrocarbons and a number of the latest compounds. Esters were then studied. It was found that wholly aliphatic esters give low film strength. Similarly, aliphatic acids when esterified with an aromatic alcohol gave low film-rupture values. Aromatic acids when linked with either low or moderately high molecular-weight aliphatic alcohols gave somewhat higher results. When the molecular weight of the alcoholic part in the molecule greatly exceeds that of the acidic part, or vice versa, the film-rupture strength usually tends to be high, whereas the film-rupture strength is low when the molecular weights of the two parts of the molecule are of the same order. The introduction of a nitro- or amino-group into an ester has little effect. Aromatic ketones do not promise much of value. Data are presented on the effect of numerous sulphur compounds. In considering chlorine compounds it was found that less than three chlorine atoms in the benzene or naphthalene nucleus do not give a compound that improves the film-rupture strength or materially affects wear. The position of the halogen atoms in the nucleus affects the improvement obtained. Compounds in which halogen atom is additively combined seem to merit special attention as addition agents. Results on a number of nitro compounds are reported. The introduction of one nitro-group into the nucleus produces an improvement that is somewhat increased by the introduction of a second. A third, however, results in a surprising loss of activity. The introduction of an alkyl substituent into chlorinated aromatics does not have a great effect. From the many nitro compounds studied the authors state that it seems reasonably safe to assume that all aromatic compounds containing chlorine are improved in film-carrying capacity when a nitro-group is incorporated within the molecule, particularly when the molecule contains at least two halogen atoms. Data on a number of mixtures of compounds are reported in the article. The discussion following the article presents a number of interesting observations.

An instrument for Measuring the Ignition Quality of Diesel Fuels, W. H. BROWNE, *S.A.E. Journal* **48** (1941) pp. 148-53T.

The Caterpillar "cetane valve" can be used to determine cetane numbers through throttling the intake air of a single-cylinder test engine until the engine misfires. By this procedure the cetane valve of 6 to 8 fuels per hour can be measured. The results are in good agreements with C.F.R. ratings.

Study of Bituminous Mixtures on Road-Testing Machines, C. MACK, *Jour. Soc. Chem. Ind.* **60** (1941) pp. 111-120.

The investigation reported deals with the problem of adhesion of bitumen to mineral aggregate. Simple methods for estimating adhesion are outlined. It is shown that the adhesion of bitumens can be improved by

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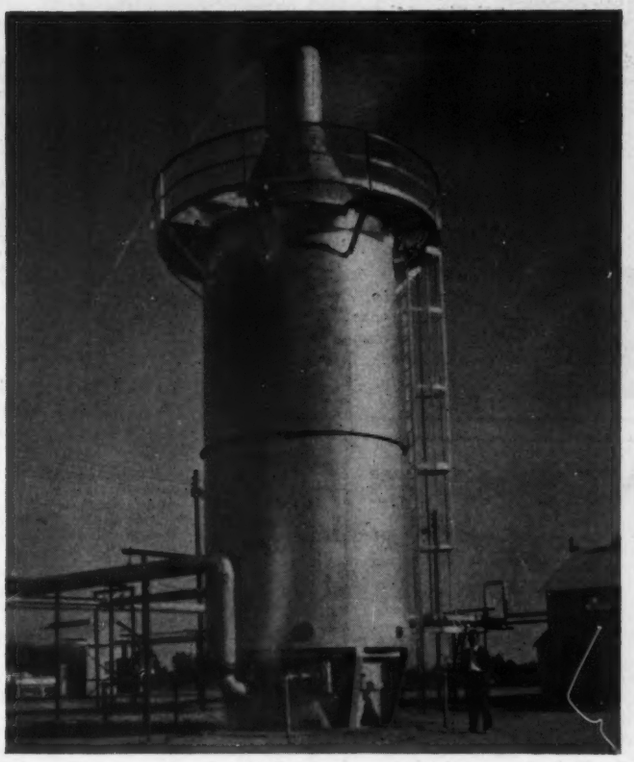

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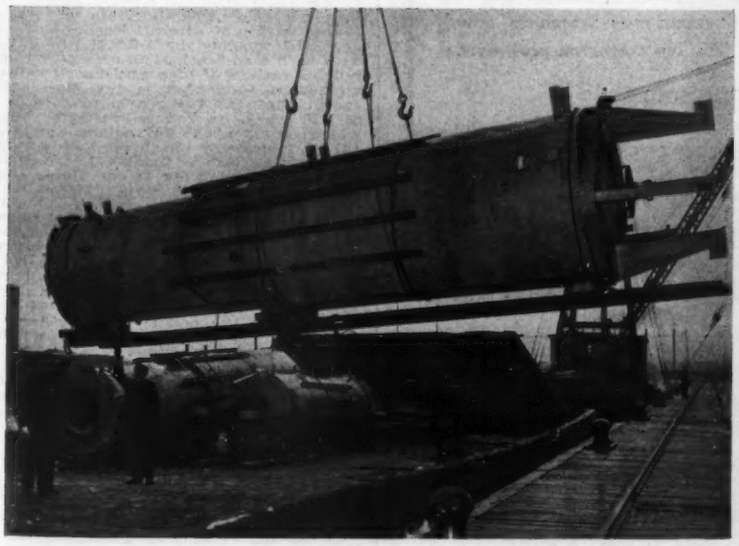

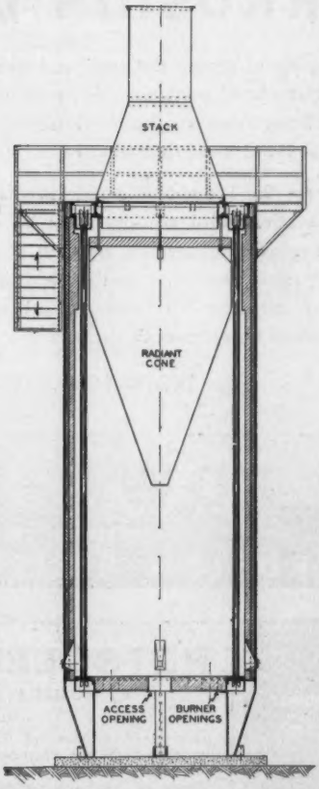

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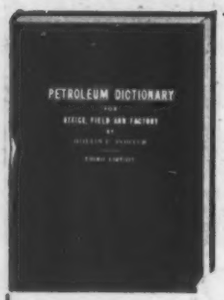

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the addition of certain agents. Use of road-testing machines affords a practical means of studying the problem of adhesion and permits the study of various other factors, such as temperature and traffic, that influence the stability of bituminous pavements. Detailed description of the construction and operation of two different machines used are given. Careful temperature control during the test is essential. The stability of a paving mixture increases with decreasing temperature. Whereas a paving mixture prepared with one type of bitumen shows an abrupt increase in stability at a temperature 15° F. below its softening point, the same mixture prepared with another type of bitumen of higher viscosity shows a continuous and smaller increase in stability with decreasing temperature. Improving the adhesion of bitumen through the use of addition agents results in a considerable increase in the life of a bituminous mixture. The relative improvement in stability caused by addition agents is also influenced by temperature as determined by tests on one machine, but not by tests on the other machine. Increasing the speed of the wheel results in an increase in stability which is higher than would correspond to the ratio of the speeds. A comparison of the results obtained by use of the two machines for the same paving mixture indicates that stability is influenced by: (1) temperature; (2) speed of the wheel; (3) amount and distribution of traffic; (4) surface contour of the pavement; (5) scuffing action of the wheel. Other factors remain to be investigated. In view of the difficulty in controlling all of the factors affecting the stability of a pavement on the road, it seems to be impossible at the present time to correlate road results with those obtained by use of the test machines. Much more knowledge must be obtained before this desirable result can be achieved.

The Wear-Load Characteristics of the Four-Ball Test with Various Lubricants, R. SCHNURMANN, *Engineering,* **149** (1940) p. 567.

The conditions that contribute to wear during sliding are oxidation at the surface, the thinning of the boundary film so that it becomes somewhat adhesive, and the existence of an electric field. No evidence was found to indicate that welding of the contacting surfaces occur at the moment of seizure. The combined action of the several above factors cannot result in anything but irregular time-friction charts. The lower the dielectric breakdown strength the better the quality of the gear lubricants insofar as wear is concerned. It is believed that the wear-load characteristic can be used as a criterion for the selection of lubricants for various bearing materials and conditions of load and speed.

Extension of the Octane Scale Above 100 O.N., Report and Recommendations of the Institute of Petroleum Knock-Rating of Aircraft Fuels, Panel, *Jour. Inst. Petr.* **27** (1941) pp. 188-90.

The publication is a report and recommendations of The Institute of Petroleum Knock-Rating of Aircraft Fuels Panel. It was decided to employ the A.S.T.M. Motor Method with such modifications as necessary to obtain reliable ratings of high anti-knock value. The method recommended is the Motor Method except that (a) the spark advance is fixed at 17° early, to reduce unsteady knocking which occurs above 100 octane number, and (b) the bouncing-pin lower-leaf spring-tension may have to be increased to prevent the pin from bouncing due to the higher combustion pressures. Tensions up to 300 grams have been found to be satisfactory. To obtain continuity of scale it has been decided to employ the secondary reference fuels recommended by the Institute of Petroleum. Primary reference fuel is to be pure iso-octane + 4 mls. tetraethyl lead/Imperial gallon and n-heptane + 4 mls. tetraethyl lead/Imperial gallon. An octane number calibration table for the extension of the octane scale by the C.F.R. motor method above 100 octane number is given, as well as a curve.

Tentative Method for Knock-Rating of Experimental Aviation Fuels of Over 100 O.N., *Jour. Inst. Petr.* **27** (1941) p. 191.

The Institute of Petroleum's tentative method for knock-rating of experimental aviation fuels over 100 octane number is described. The apparatus and method are those of the Institute as described in the Third Edition, 1935, of the "Standard Methods for Testing Petroleum and its Products," except that a fixed ignition setting of 17° early is used, and the bouncing-pin lower-leaf spring-tension is increased to prevent the pin from bouncing as a result of higher combustion pressures. A maximum spring tension of 300 grams can be used. The method is intended primarily for the testing of experimental types of fuels of over 100 octane number. The primary scale is in terms of pure iso-octane and n-heptane up to 100 octane number, thence by extrapolation up to 120 octane number.

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The one-inch-per-day speed of the recorder is made possible by inkless recording mechanism which makes an impression by pressing the chart against a typewriter ribbon. The inkless feature obviates the freezing and evaporating difficulties in extreme temperatures, and the recorder is designed to function accurately in temperatures ranging from —10° to —120° F.

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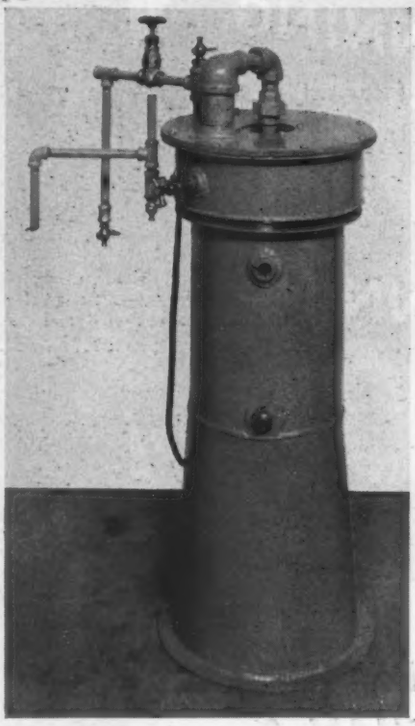
A stripper or solvent vaporizer operating on the steam distillation principle, designed for use with the company's rotary high-vacuum pump, has been announced by F. J. Stokes Machine Company, Philadelphia. Pump-sealing oil is passed through the device before it is returned to the oil reservoir.



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It is designed to continuously remove low-boiling-point solvents and other volatiles which may be dissolved in the pump oil, enabling the pump to maintain high vacuum. Solvents removed by the vaporizer can be recovered if desired.

The vaporizer is intended as an auxiliary device to meet special conditions, and not a substitute for an oil clarifier to remove condensed moisture and foreign matter from the pump oil.

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An arc welder for use on light-gauge metal, castings and drive shafts, general maintenance and light production work, designated Midget Marvel WT-1, has been announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

The unit is issued complete with all accessories, including electrode lead and holder, work lead, helmet, electrodes and primary cable for hooking to the power line. Adjustment of welding current over a range from 20 to 140 amperes is provided by 15 steps, with proportioned increments between steps. Full load rating is 110 amperes, 30 minutes, 30 load volts when used on 220-volt, 60-cycle lines.

Dimensions are 14½ by 12⅛ by 20 inches long, and weight is 160 pounds. Welder is supported on casters to facilitate mobility.

Turret Lathe

SOUTH BEND LATHE WORKS

South Bend Lathe Works, South Bend, Indiana, has designed a new 16-inch turret lathe for rapid production on chucking operations and bar work has been announced by the South Bend Lathe Works. This lathe has a 16¼-inch swing over the bed ways and saddle wings, 9⅝-inch swing over the tool post saddle cross slide, 1⅜-inch hole through the headstock spindle and 1-inch capacity through the collet.

The ram type turret has both power feed and hand feed, with automatic indexing and individual stop for each of the 6 turret faces. A quick change gear box provides 48 changes of turret power feeds, also 48 changes of both the cross and longitudinal feeds for the tool post carriage and a series of 48 screw threads, 4 to 224 per inch. Provision is made for changing the direction and speed of the turret feeds with relation to the carriage feeds. Twelve spindle speeds ranging from 10 to 731 rpm are available. A two-speed motor permits quick change from high to low speed for reaming and tapping operations.

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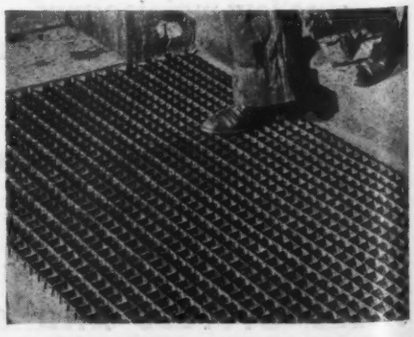
A steel mat, designed to lie flat on the floor and not to creep or wrinkle, has been announced by William F. Klemp Company, 6601 South Melvina Avenue, Chicago.

The mat is made from ⅝ x 0.065-inch



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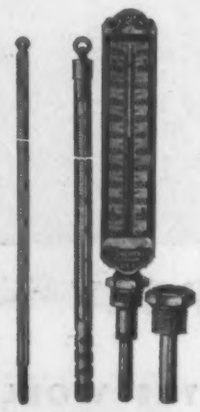

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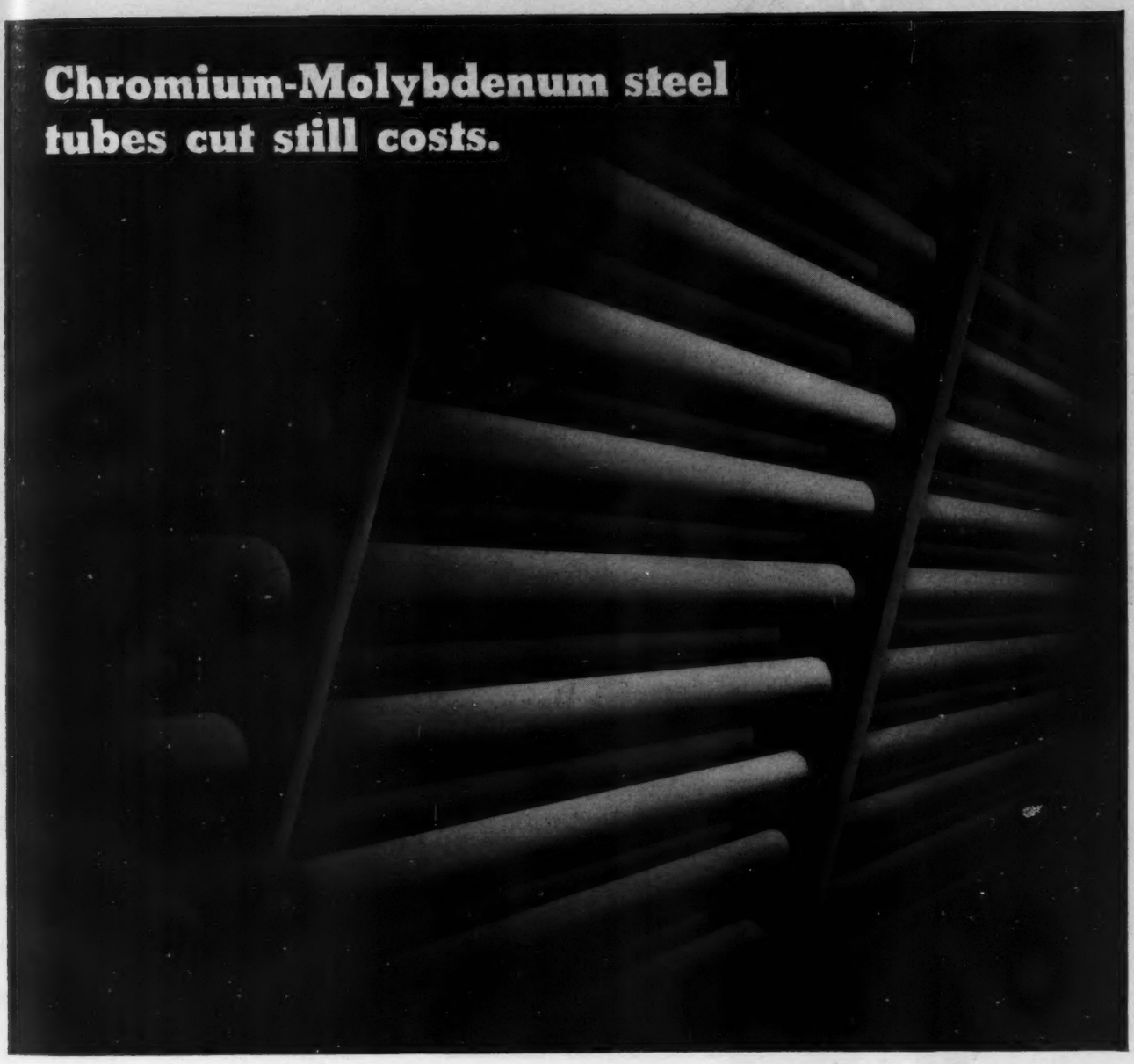
Mfgrs. Industrial, Laboratory, Recording & Dial Thermometers

2513 NORWOOD AVE., CINCINNATI, NORWOOD, OHIO

Canadian Plant: King & George Sts., Toronto, Canada

Chromium-Molybdenum steel tubes cut still costs.



Still tubes of Chromium-Molybdenum (4-6% Cr-0.50% Mo) lessen the headache of keeping high temperature (1200°F.) stills on the line.

The steel has high creep strength plus good resistance to corrosion and oxidation. It is practically free from temper brittleness. In addition, longer intervals between cleanings are possible because thicker coking is tolerable. Substantially longer tube life results. Stills with Chromium-Molybdenum tubes show less down time, and considerably reduced maintenance and replacement expense.

Send for free book, "Molybdenum in Steel" for data on Molybdenum steels that are increasing efficiency and reducing costs in oil refineries.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • CALCIUM MOLYBDATE

Clima[illegible]-ly-[illegible]m [illegible]mpany
500 Fi[illegible]ve[illegible] • [illegible]w York City

MOLY

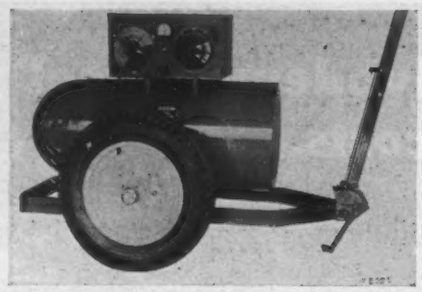
steel formed into a 1¼ x 1¼-inch mesh. It is offered cut to any length up to 25 feet and any width up to six feet, and in multiples of those dimensions. Ends of adjacent mats are joined together with a single stringing wire. All edges are turned and finished. The mat is flexible and can be rolled like a rug.

Welding Machine Trailer

THE LINCOLN ELECTRIC COMPANY

A 2-wheeled pneumatic-tired trailer for mounting arc welding machines to gain portability in shop, yard or on the road, has been announced by The Lincoln Electric Company, Cleveland.

Designed for mounting either the company's SAE 200 to 600 ampere AC motor-driven unit, or Type SA 200 engine driven unit, the trailer can be used for road towing up to 30 miles an hour.



Lincoln Trailer with Motor-Driven Unit

It is of arc welded steel construction throughout.

Mounting is by four bolts in frame of trailer, which register with holes in lugs on the welding machine. Combination tow bar and standing support has a hand-operated ratchet arrangement for locking support arm in position. The unit measures 66 inches long, 42 inches wide, 16 inches high, and weighs 282 pounds. Tires are 16 x 5.50.

Flexible Coupling

THE FALK CORPORATION

A new coupling for floating shaft requirements, designated Type P Piloted, has been added to the line of The Falk Corporation, Milwaukee. It is designed for use with exhaust draft fans, and horizontal and vertical pumps.

The coupling combines a resiliency and shock cushioning section with a low angle universal joint action to eliminate necessity of an outboard bearing on extended shafts, or auxiliary bearings on intermediate shafts. It is constructed entirely of steel, and consists of two hubs, one of which carries an integral flange to which the cover is secured, a special tempered steel member forming a complete cylindrical grid member and flanged steel cover secured to the hub flange with capscrews.

It is available in three types: single piloted, to support a long shaft extension without using an inboard bearing on the extended shaft; double piloted horizontal, an arrangement of two type P couplings with connecting shaft for super calender drives through motor room walls; and double piloted vertical, consisting of two type P couplings and the connecting shaft for use on vertical drive applications where it is desirable to have considerable distance between the driving and driven equipment.

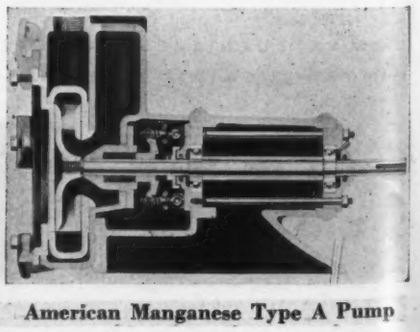
Pump

AMERICAN MANGANESE STEEL DIVISION

Two horizontal-shaft pumps, Types A and T, similar in design except that Type T has intake opening horizontal and concentric with shaft, have been announced by American Manganese Steel Division of The American Brake Shoe & Foundry Company, Chicago Heights, Illinois.

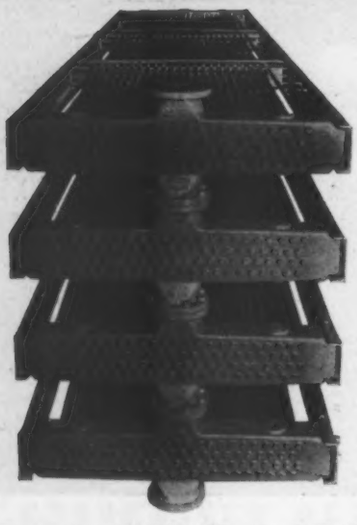
They are available in sizes from ¾-inch to six inches, in capacities up to 1400 gallons-per-minute, and for operating heads up to 100 feet. They feature clamp-bolt construction of water end, a bearing arrangement designed to provide proper alignment, sealed bearings, a readily accessible stuffing box, and self-priming. Impellers available are 2-, 4- and 6-vane shrouded type, and 4-vane open type.

Construction materials available, with choice determined by extent of abrasion or corrosion under which the pump will operate, include manganese steel, chromium-nickel alloys, white iron, nickel-iron, brass, bronze and other cuprous alloys.



American Manganese Type A Pump

"COYNCO"



HEAT EXCHANGERS in "Your Process"

•

"Coynco" Atmospheric Stratube Sections

Note features of design such as: Hot Dip Galvanized Steel framework after fabrication; Full Floating Head; Red Wood filled tube racks; Standard Pipe size extended head tube plugs; Staggered Tube spacing allows adequate cleaning lanes. All "Coynco" Standards.

"Coynco" Shell and Tube Heat Exchanger Units

"Coynco" Shell and Tube Heat Exchanger Units, tested and ready for shipment.

All units of conventional design and arrangements as to tube bundle, channel, assembly, connections and general workmanship.

In accordance with A. P. I.-A. S. M. E. code standards.

Joseph A. Coy Co., Inc.

3515 Dawson Road Phone 3-9196

TULSA, OKLAHOMA

Branch Office—304-305 Rule Bldg., Amarillo, Texas

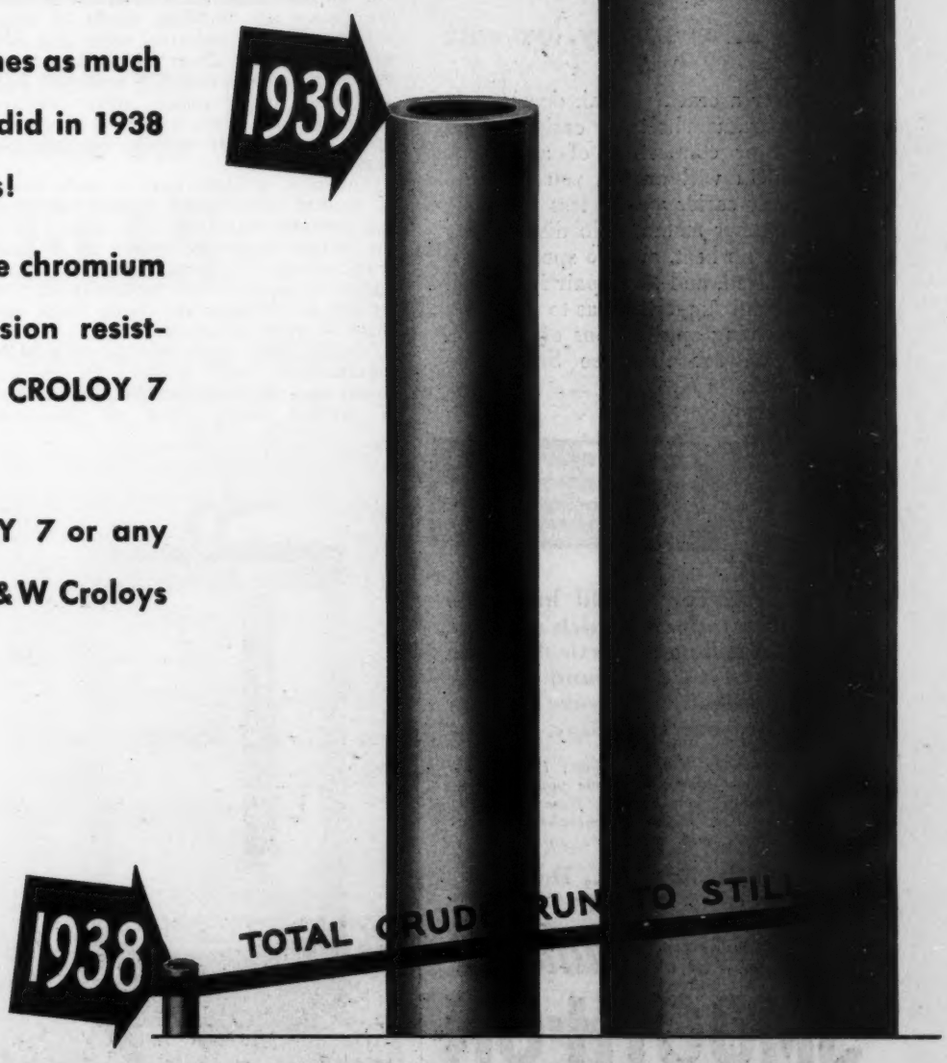
REFINERS RECOGNIZE THE CONOMY of CROLOY 7

(6.30—8.00% chromium;
0.50—1.00% silicon;
0.45—0.65% molybdenum)

In 1940, refiners purchased 24 times as much B&W CROLOY 7 Tubing as they did in 1938 —a 2400% increase in two years!

In CROLOY 7, you get 40% more chromium than in Croloy 5. Where corrosion resistance is of greatest importance, CROLOY 7 saves money.

Full technical data on CROLOY 7 or any other of the complete range of B&W Croloys will be sent on request.



Lengths of tubes at right are proportional to tonnage of B & W CROLOY 7 Refinery Tubes purchased each year.

TA-11

BABCOCK & WILCOX TUBES

HOT FINISHED COLD DRAWN ALLOY STEELS CARBON STEELS

THE BABCOCK & WILCOX TUBE COMPANY, BEAVER FALLS, PA.

". . . now, we always keep Smooth-On for emergencies"

During the test of a centrifugal pump, the casing cracked. Time was valuable, because delay would have involved a penalty. The engineers filled the crack with Smooth-On No. 1, and a day later the tests were resumed. The test was completed successfully. The operating engineer reports that throughout the following five years during which he remained at the plant, the pump was in steady service and the repair continuously tight.

Many other speedy, low-cost repairs

Wherever a crack or leak develops in an apparatus shell or casing or at a joint or connection of any kind, Smooth-On will enable you to make the repair easier and at less cost than by any other method. No dismantling of parts, no heat, and no special tools are required, and the repair is lasting. For helpful suggestions as to the many money-saving applications of Smooth-On, write for the free Smooth-On Handbook.

FREE 40-PAGE HANDBOOK
if you send us your name and address on a post card

Every engineer should have this valuable handbook which contains many ingenious, practical repair guides not to be found in any other publication. Be sure to write today for your free copy.

Buy Smooth-On No. 1 in 7-oz., 1 or 5-lb. can, or 25 or 100-lb. keg from your supply house or if necessary direct from us. For your protection, insist on Smooth-On, used by engineers and mechanics since 1895.

Smooth-On Mfg. Co., Dept. 11
570 Communipaw Ave., Jersey City, N. J.

Do it with
SMOOTH-ON
The iron repair cement of 1000 uses

Rotameter

FISCHER & PORTER COMPANY

A rotameter, designated Stabl-Vis, has been announced by Fischer & Porter Company, Hatboro, Pennsylvania.

The instrument consists essentially of a transparent, vertically mounted tube with a precision-bored inside taper, within which floats a bob. Fluid to be measured passed upward through the tube, and the bob rises to a position at which its weight is counter-balanced by the thrust of the flowing fluid. Position which the bob attains measures rate of flow, which is read directly on a scale outside the tube.

The rotameter is designed for measurement of liquids, vapors and gases. Various construction materials are available to combat corrosive conditions. The instrument, which is built for both laboratory and commercial purposes, may be built to handle flow ranges up to 200 to 1.

Transformer Arc Welders

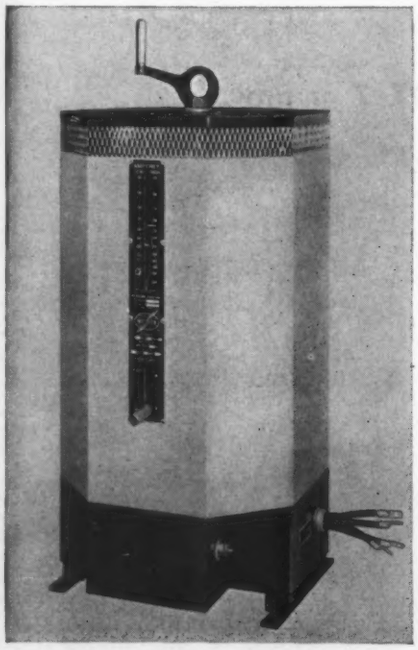
WILSON WELDER & METALS COMPANY

A new line of AC Transformer Welders in 300, 500, 750 and 1000 ampere capacities has just been announced by Wilson Welder and Metals Company, 60 East 42nd Street, New York.

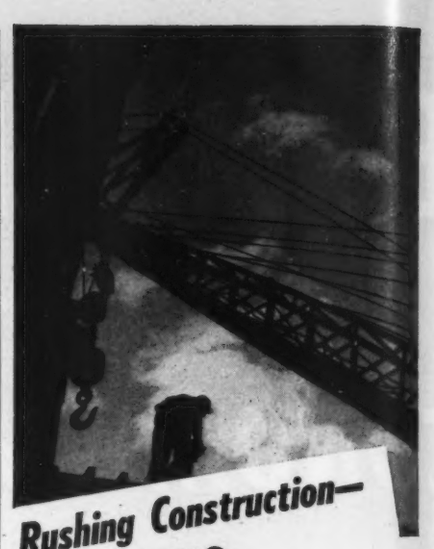
Known as Model TW, these welders are self-contained units designed to meet the heavy arc welding needs of shipyards, railroads and steel mills. For 220, 440 or 550 volts, 25 or 60 cycle current. When arranged for 220 and 440 volt operation, single phase, either voltage can be brought into use by a reconnection of the leads which are brought outside the unit.

The new welders have a wide range of current output and continuous stepless current regulation is provided over the entire range by means of a hand crank on top of the machine. This crank makes it possible to rapidly shift the setting as changes are made from one class of work to another.

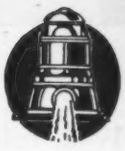
Model TW conforms to N.E.M.A. requirements, and is said to operate cooler and therefore last longer, because of divided construction of the coils



Wilson Model TW Welder



Rushing Construction—
SPEEDING PRODUCTION



CLATTERING air hammers, roaring bulldozers and clanging well casing noise dins the air throughout the country. Defense projects are being rushed—production is going up,—up—and up! But the entire program is moving on a simple life necessity—Water!

Almost before the first transit is leveled, Layne men are on the job, rigs are up and the drills are biting through soil, clay, rock and on to water bearing formations. In record time you'll hear the hum of powerful motors and the splashing of cool clear water. Such is the tempo of today's unparalleled activity as the Nation faces an unpredictable future.

Keyed to the ever increasing and extremely urgent need for speed in production is Water! And wherever the Pump and Well is of Layne build, there you will find dependable performance no matter how heavy the load or prolonged the run.

Never has the Layne Organization been so keenly alert to its task of producing great quantities of water with utmost speed. Never has it been operating more efficiently. If you need more water to further speed production, write or wire

LAYNE & BOWLER, INC.
Memphis, Tenn.

LAYNE
PUMPS & WELL WATER SYSTEMS

AFFILIATED COMPANIES

Layne-Arkansas Co.	Stuttgart, Ark.
Layne-Atlantic Co.	Norfolk, Va.
Layne-Central Co.	Memphis, Tenn.
Layne-Northern Co.	Mishawaka, Ind.
Layne-Louisiana Co.	Lake Charles, La.
Layne-New York Co.	New Cork City.
Layne-Northwest Co.	Milwaukee, Wis.
Layne-Ohio Co.	Columbus, Ohio.
Layne-Texas Co.	Houston, Texas.
Layne-Western Co.	Kansas City, Mo.
Layne-Western Co. of Minnesota	Minneapolis, Minn.
Layne-Bowler New England Corp.	Boston, Mass.
International Water Supply	London, Ontario, Can.

All Taylor Forge Fittings are critically inspected for circularity of ends, accuracy of dimensions, and smoothness of inside wall.
6"STD. TAYLOR FORGE WELDELL PAT. 1936805

An extra operation for us provides extra value for you in WeldELLS

ONE of the big reasons practical men prefer WeldELLS is because these *engineered* fittings line up so perfectly. And the reason WeldELLS do line up so precisely, so easily, is because every one is given a *truing operation* to bring the fitting to *exact* size before machining bevel and land. Incidentally that's also why both bevel and land are so accurate and uniform in WeldELLS.

Of course it costs us something to perform this operation—and we could "get by" without it. But we believe that the extra value provided fully justifies the expense.

So here again the Taylor Forge principles of sound engineering design, maximum simplicity, utility and economy, bring added value to users of welding fittings.

And remember that with all their extra value features Taylor Forge Fittings cost no more than other makes.

• You'll find the complete story in our big Catalog 401—216 pages of usable information and valuable engineering data. Write for it today.

TAYLOR FORGE & PIPE WORKS

General Offices & Works: Chicago, P. O. Box 485 • New York Office: 30 Church St.
Philadelphia Office: Broad Street Station Bldg.

OTHER EXTRA VALUE FEATURES

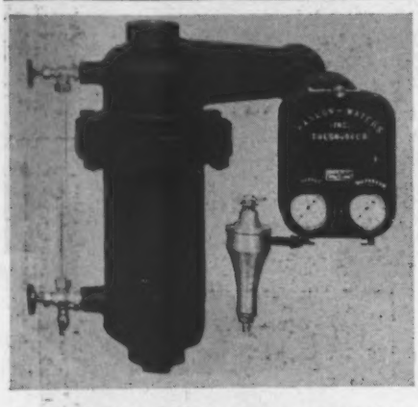
In addition to the features described opposite, WeldELLS have the following advantages which are combined in no other welding fitting:

1. **Seamless**—greater strength and uniformity.
2. **Tangents**—keep weld away from zone of highest stress—simplify lining up.
3. **Precision quarter-marked ends**—simplify layout and help insure accuracy.
4. **Permanent and complete identification marking***—saves time and eliminates errors in shop and field.
5. **Selective reinforcement**—provides uniform strength.
6. **Wall Thickness never less than specification minimum**—assures full strength and long life.
7. **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
8. **The most complete line of Welding Fittings and Forged Steel Flanges in the World**—insures complete service and undivided responsibility.

*Since the marking is pressed into the metal before forming, and since the manufacture of the fittings is carried out at a forging temperature, each in effect receives a heat treatment after the operation. The indentations have no sharp corners or edges and the marking has no effect on the strength of the fitting.

which allows greater surface area to be exposed to the cooling air. All coil covering is spun glass fibre, heat-resistant, Class BB insulation, providing trouble-free operation even if used continuously at maximum settings.

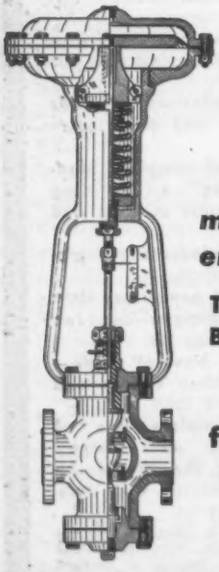
On 60-cycle units, all sizes are fan cooled except the 300-ampere size, which is cooled by natural draft. On 25-cycle units, all sizes are fan cooled. The 60-cycle units have high- and low-range switches, while the 25-cycle units have only one range. This low-range switch provides current adjustments on the 500-ampere size from 40 to 650 amperes. Power factor correction is included in all models for 60-cycle operation except the 300-ampere size. Welders built for 25-cycle operation do not have power factor corrected. Efficiency of all the TW units is approximately 80 to 85 percent, an announcement says.



H-W Type 850 Level Controller

COMPANIONS

QUALITY PERFORMANCE



H-W Type 86 Motor Valve

Ask the men who operate them—

THEY ARE OUR BEST SALESMEN

Send for complete information

HANLON-WATERS, INC.

TULSA, OKLAHOMA

New York, Chicago, Pittsburgh, Philadelphia, St. Louis, Denver; Shreveport and Lafayette, La.; Fort Worth, Houston, Corpus Christi, Longview and Odessa, Texas.

BUSINESS NOTES

Michigan Alkali Company Moves Sales Headquarters to Detorit

The Michigan Alkali Company has consolidated its general sales and executive offices, which are now located in the Ford Building, Detroit.

An Eastern branch office will be maintained at 60 East 42nd Street, New York. Other branch offices are located in Chicago, Cincinnati and St. Louis.

Chain Belt Company Makes Changes in Sales Department

A number of changes have just been announced by Chain Belt Company of Milwaukee.

W. B. Marshall, who has been assistant sales manager of the Conveying and Engineering Products Division of the company, has been made sales manager of that division. Mr. Marshall has been with the company since 1920. Besides being assistant sales manager, he has been in charge of the development and sales of sanitation equipment and has also had experience in field sales work. He graduated from Sheffield Scientific School of Yale University in 1921.

Another change brings B. E. Sivyer, former San Francisco branch manager, to Milwaukee as assistant sales manager of the Chain Belt and Transmission Division. Sivyer has been with the company 10 years and of that time spent 4½ years in San Francisco. He attended the University of Wisconsin.

Replacing Sivyer as branch manager at San Francisco is S. Y. Warner who joined Chain Belt Company in 1930, the same year he graduated from Sheffield Scientific School of Yale University. Warner has recently been in the company's Los Angeles office and the California oil fields.

Ohmite Manufacturing Company Completes New Factory Addition

Ohmite Manufacturing Company, manufacturers of rheostats, resistors, tap switches, and chokes, has recently completed an addition to the factory on West Flournoy Street in Chicago.

The enlarged plant, extending the frontage to several hundred feet, doubles the production space and greatly expands the company's facilities.

This current expansion is the second within a period of a few years.

Griscom-Russell Moves Houston and Tulsa Offices

The Griscom-Russell Company has moved its Houston office to 1548 Esperson Building, and its Tulsa office to 810 Petroleum Building.

A. K. Hegeman Represents Clark Bros. on West Coast

Clark Bros. Company of Olean, New York, manufacturers, announced a change in address of its Pacific Coast office and warehouse and the appointment of A. K. Hegeman as West Coast manager.

Hegeman is a graduate of the University of California, college of mining engineering. Following his graduation he served in the World War as a lieutenant of Field Artillery. At the close

Sales forces of Pittsburgh Equitable Meter Company and the company's National Meter Division were consolidated during a series of meetings held at various district offices. Attending one of the meetings were, first row, Ross Burns, Fred Hartmann, W. F. Rockwell, A. E. Higgins, P. C. Kreuch and W. N. Calkins; second row, H. D. Leisenring, Harry H. Clark, R. P. Parshall, W. J. Klevorn, D. G. Kappelman and Paul Payton; back row, N. W. Simcoe, Clyde Hum, George Bender, A. H. Wille and Dan Gannon.

BETTER OIL FOR NATIONAL DEFENSE!

...with Furfural Refining and Solvent Dewaxing

IN today's warfare of machinery the need for dependable lubricants, for both the making and the operation of modern mechanized equipment, is a present military problem.

Thanks to the Furfural Refining and the Solvent Dewaxing Processes, these needed quality oils can be produced from many crudes at low cost and relatively low investment.

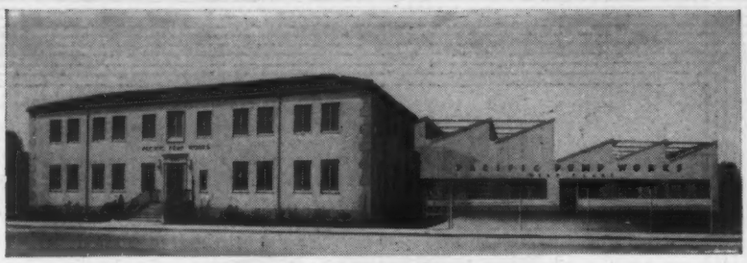
TEXACO DEVELOPMENT CORPORATION

A Subsidiary of The Texas Corporation

26 Journal Square • Jersey City, N. J.

of the war he engaged in mining engineering work in Utah until 1923, when he became sales manager for Cochise Rock Drill Company, of Los Angeles. The following year he entered the employ of Smith-Booth-Usher Company, of Los Angeles, where he has since been engaged in oil field sales work. Smith-Booth-Usher Company has been Clark Bros. Company's Pacific Coast representative for the past 10 years.

The new sales office and warehouse are located at the plant of Pacific Pump Works, Bicket Street and Slauson Avenue, Huntington Park, California.



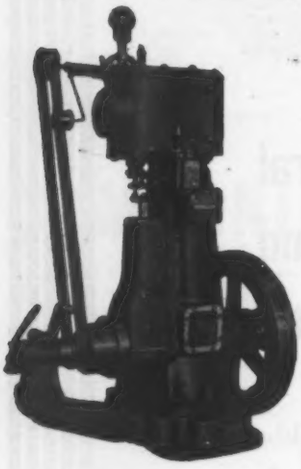
Clark Bros. Company has opened a Western office quarter with Pacific Pump Works at Huntington Park, California.

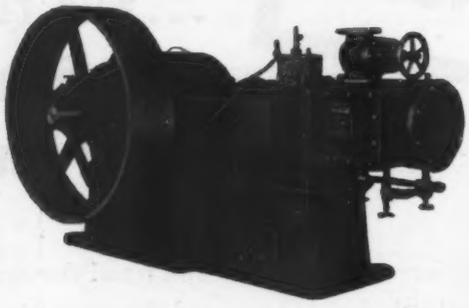
George B. Ewing, Jr., has joined the staff of sales engineers attached to the Houston office of The Foxboro Company. Ewing, who has had wide experience in the machine and tool-making industries and in petroleum refining operations, is a graduate of the University of Arkansas and the engineering course at the University of Alabama.

TROY-ENGBERG STEAM ENGINES

Sure and Steady Drives

for pumps, compressors, blowers and other refinery equipment.





Probably no other drive in a refinery is as vitally important as the one hooked up to a charging pump . . . and it is on charging pumps that hundreds of Troy-Engberg Steam Engines are in use today. That, in itself, should be an index of their dependability.

Other useful features include high-starting torque and capacity for handling heavy overloads; wide speed range easily controlled automatically; low sustained steam and oil consumption; elimination of fire hazard.

Write for our general catalogue so that you will have it available when next considering drives.

TROY ENGINE & MACHINE CO.

Established 1870

969 RAILROAD AVE., TROY, PA.

9-TEM-3

James H. Maguire has retired as works manager of Haynes Stellite Company, Kokomo, Indiana, and will continue with the company in a consulting capacity. F. T. McCurdy, plant superintendent, has been named general superintendent in charge of production and operating departments; J. R. Brown, former production manager, is assistant superintendent, and H. C. Fretz, general foundry foreman, has been named assistant to the superintendent.

C. C. Brownley has joined the sales staff of Milby-McKinney, Baltimore. His sales engineering work will involve Cochrane water conditioning equipment, Armstrong traps, Goulds pumps, Ruggles-Klingeman valves, Wagener steam pumps, and D. E. Whiton turbines.

Edward L. Biersmith, Jr., has been promoted to production manager of Columbian Steel Tank Company, Kansas City, Missouri. Biersmith, formerly assistant sales manager of the company, has been in Washington, D. C., the past year, representing the firm's interests in fulfilling many national defense contracts. Ironically enough, Biersmith's job now changes from that of obtaining government contracts to that of producing them. He is fitted for the job of production management having been associated with the Ford Motor Company in former years. At one time, being night superintendent of the Ford Kansas City branch. Biersmith has been connected with the Columbian Steel Tank Company for the past twelve years.

E. L. Biersmith, Jr.

J. Walter Snavely, Houston district manager for Chain Belt Company for seven years, has been transferred to the sales department of the company's conveying and engineering products division at Milwaukee. A graduate of the University of Wisconsin, he joined the company in 1927 as a student apprentice, and during the following three years received factory training in various departments.

J. W. Snavely

W. A. Pitts, Oklahoma City representative since 1936, has been named

SARCO BLENDERS

For Cooling Water Control

Close control of jacket water temperatures on internal combustion engines and compressors saves three ways—(1) It assures operation at the most efficient temperature—(2) It protects the unit against overheating—(3) It conserves the water supply.

In many plants, there is an important additional saving—because the blender can be connected so that a portion of the hot water may be used for heat exchangers, wash tanks, etc.

Sarco Blenders are made in three different types covering the range from 0 to 200 degrees Fahrenheit and from ½ inch to 4 inch pipe sizes. Ask for Catalog No. 197.

80

SARCO
SAVES STEAM

SARCO COMPANY, INC.
475 Fifth Avenue, New York, N. Y.
SARCO CANADA LTD., FEDERAL BLDG., TORONTO, ONT.

For Successful Sealing of DOWTHERM

USE DURAMETALLIC D-110 PACKING

A CASE HISTORY

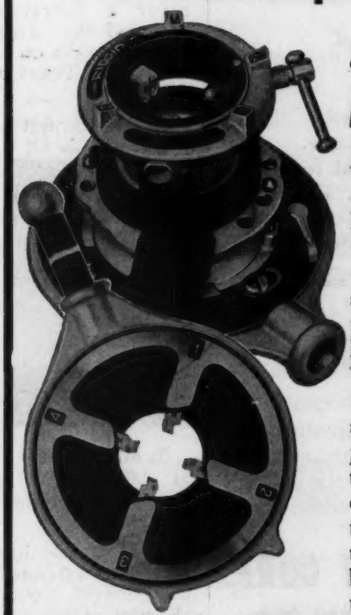
On a Dowtherm boiler installation located in a well known plant, Durametallic D-110 Packing is sealing centrifugal pumps operating at 150 lbs. pressure, 1200, 1700 and 3600 R. P. M., temperature 744° to 750°F.

"THE only packing found successful on this difficult job," so writes a customer concerning Durametallic Packing for valves and pumps working Dowtherm. You'll find Durametallic D-100 gaskets just the thing for pipe flanges in Dowtherm pump lines too. Write today if you are in search of better sealing for Dowtherm.

DURAMETALLIC CORPORATION
The PERFECT SEAL
KALAMAZOO MICHIGAN

Dependable Working Tools are Vital Weapons

Speed Your Part of the Big Job with these Work-Saver RIDGID No. 65R Pipe Threaders



Set to thread 1" to 2" pipe by an easy 10-second adjustment

Beating schedules comes natural to the miracle of voluntary American skill. . . . These self-contained No. 65R RIDGIDs help you do *your* part. They set to thread 1", 1¼", 1½" or 2" pipe of any kind in one quick adjustment—no extra dies to carry around, lose or cause delay. Instant setting workholders, practically automatic—no bushings. Clean perfect threads from hi-speed steel chaser dies. Rugged all-steel and malleable-alloy construction. . . . Save vital time and work—ask your Supply House for these RIDGID 65Rs.

THE RIDGE TOOL COMPANY, ELYRIA, OHIO

RIDGID
WORK-SAVING PIPE TOOLS

In Pumping Hot Oil —at 900°

—a recent check-up of a COLMONOY coated pump sleeve showed that this sleeve ran 2400 work hours, as compared with other hard-surfaced sleeves at 360 work hours.

The pump handled hot oil at 900°, running 3600 R.P.M.

Such resistance to corrosion and abrasion is just another reason why you should investigate the application of COLMONOY on your tough jobs.

12 Proven Reasons Why You Should Specify Colmonoy Hard Facing Alloys

1. Can be applied to all ferrous base metals.
2. Easiest of all hard facing alloys to apply.
3. Less pre-heating required.
4. Has lower melting point.
5. Flows more smoothly.
6. Less welding time required.
7. Can be hot wiped into shape.
8. Less hard facing material required.
9. Finishes to high polish, minimizing friction.
10. Maximum resistance to abrasion, corrosion and galling.
11. Does not service check.
12. Gives longer life.

Write for Catalog

Our engineers will be glad to discuss the proper application of COLMONOY to meet your individual requirements. Your letter will receive prompt attention.

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208 Midco Building, TULSA
21 Seneca St., BLASDELL, N. Y.

COLMONOY
Hard Surfacing Alloys and Overlay Metals

district manager of oil well sales at Houston, succeeding Snavely. George Hunt, formerly with a southern paper mill, has been named district manager of industrial sales at Dallas.

H. M. Hubbard

Howard M. Hubbard, president and general manager of Greenfield Tap & Die Corporation, has been named president of Elliott Company, Jeannette, Pennsylvania. He succeeds Jas. E. Watson, who on July 31 resigned as president and director. After serving with the National Guard on the Mexican border and with the Yankee Division in France during World War I, he attended Massachusetts Institute of Technology and Northeastern University, graduating from the latter school with a B. S. degree in mechanical engineering. He was connected with Bullard Machine Tool Company and Harris-Seybold-Potter Company before joining Greenfield Tap & Die Corporation.

B. Smith

Blanchard Smith, formerly with Reynolds Gas Regulator Company, has been named Mid-Continent representative for The Chaplin-Fulton Manufacturing Company, Pittsburgh. Earlier, he was connected with Westcott & Greis, Inc., Tulsa. Making his headquarters in Kansas City, he will cover a territory bounded by Iowa and Nebraska on the north and Texas and Louisiana on the south.

N. M. Barnett

N. M. Barnett has been named manager of a new Detroit branch of Bailey Meter Company, Cleveland, located in the Curtis Building. He is being assisted by R. F. Hanson and R. T. Cowan. The company has enlarged its field engineering staff, assigning L. L. Melick to duty in New York, J. F. Triolo to Philadelphia, G. M. Wallace to San Francisco, B. F. Elias to Cincinnati, and D. E. Smith to Buffalo.

D. G. Baxter has been appointed general superintendent in charge of the Copperweld Steel Company's plant at Warren, Ohio. A graduate of Ohio Northern University, he previously had been associated with American Steel &

POSITION WANTED—Pressure Vessel Designer now employed with six-year refinery experience with both Engineers and Fabricators contemplates change. Capable of complete design, also estimate, spec writing and ordering material. Pleasing personality coupled with thorough knowledge of equipment and trade. Codes and Specs of companies, would also qualify as sales engineer. Box 28, c/o The Refiner, Houston, Texas.

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Portable DRUM CLEANER

FAST:	Two to five minutes cleans average size drum.
EFFICIENT:	Container is left absolutely clean and free of any foreign matter.
MODELS:	One, operating with 40 lbs. pressure, is for cleaning drums used for the lighter oils. The other, operating with 60 lbs. pressure, is for practically all petroleum products. Constructed for operation in hazardous locations.

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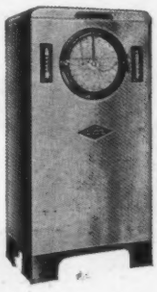
IMPROVED AC-ME RECORDING GRAVITOMETER



Is simple in construction and operation; it gives an accurate record of the specific gravity of gas; it is automatically compensated for atmospheric temperature and barometric pressure variations.

For full description of new gas testing instruments and laboratory apparatus, write for catalog No. 26-A.

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TREAT A HARDENED PACKING LIKE A WEAKENED PITCHER-TAKE IT OUT OF THE BOX BEFORE A SCORE OCCURS!

. . . and while you're about it, replace that old packing with a

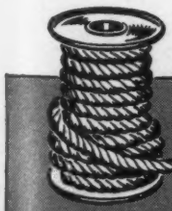
FREE WORKING SAMPLE of PELRO* SELF-LUBRICATING PACKING

*REG. U. S. PAT. OFF.

To receive a generous test sample of any of our long-wearing packings, just send us your name and address and specify the service conditions and size of the packing.

SAVE YOUR SHAFTS WITH PELRO*

Avoid scored shafts in your plant by using Pelro Packing. Scoring is caused by hardened packing—but PELRO stays soft! There's more lubricant in Pelro—impregnated in every strand **before** braiding, and **the lubricant is not washed out by gasoline or solvents.** That's the reason why Pelro lasts two to three times longer than other packings. Change to Pelro. You'll banish shaft scoring and cut yearly packing costs as well.



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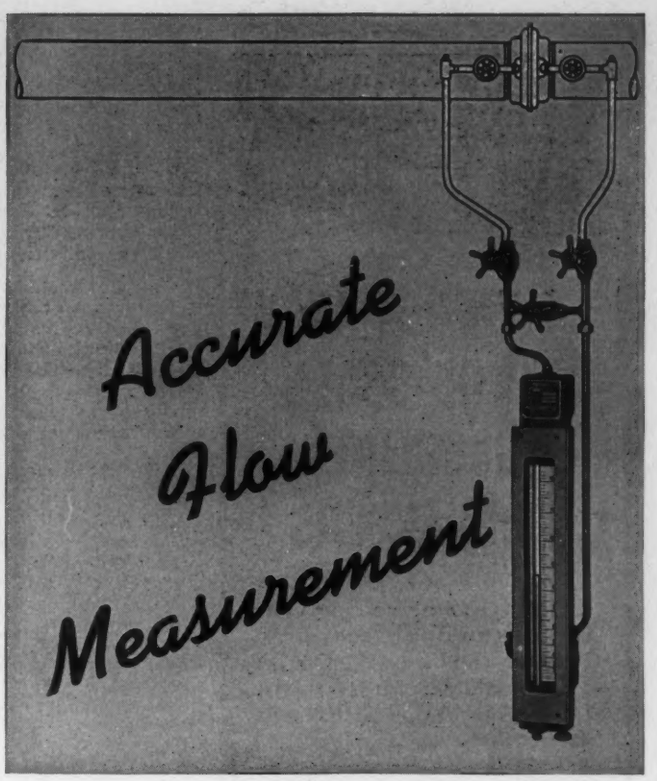
PALMETTO *for steam, hot water, air.* PALCO *for water.* PELRO *for oils.* CUTNO *for alkalis.* SUPERCUTNO *for acids.* KLERO *for foods, etc.* PALMETTO SUPERSHEAT **PACKINGS**

9 out of 10 who try them, buy them



OF WATER, AIR, GAS, STEAM PRESSURES TO 250 LBS.

● The Meriam Type H—illustrated herewith—is an extremely accurate single column direct reading indicating flow meter—which costs, complete with valves, piping and scale, as little as $50.00 each.

These meters indicate flow by measuring the pressure drop across a calibrated orifice inserted in the line, and are provided with a return well to prevent the indicating fluid from being blown into the line, and lost, if the differential should exceed the meter's range. Pressures are taken directly, or through seal pots when steam, hot oil, or corrosive substances are involved. No springs, cams or levers are used, consequently the meters are permanently accurate and do not wear out or require adjustment. Thousands of these meters are already in use, in every branch of industry. Bulletin No. 18 gives full details. Send for a copy.

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CLEVELAND, OHIO

Manometers, Meters, and Gauges for the accurate measurement of Pressures, Vacuums and Flows of Liquids and Gases.

MONEY SAVING
News FOR REFINERIES
AND PRODUCERS

LOW-COST WAY TO DE-SCALE GASOLINE CONDENSERS

Is your present method of de-scaling gasoline cooling condensers costing you too much? If so, try the successful Oakite method that one Mid-Western refinery has found so easy and economical.

Simply circulate recommended solution of Oakite Compound No. 32 through system as directed. Due to its uniform, controlled action, this specially designed material thoroughly yet SAFELY dissolves insulating deposits, so that flushing removes them completely. Cooling efficiency is back where you want it. Best of all, cost is really LOW!

Save Time . . . Money ON THESE JOBS, TOO!

Also try this safe, fast-working material for de-scaling Diesel water jackets, booster pumps, compressors, vacuum condensers, "lube" oil coolers, heat exchangers. FREE 20-page booklet gives formulas for using this time-saving, money-saving material. Write for YOUR copy now!

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Representatives in All Principal Cities of the United States and Canada

OAKITE *Certified* CLEANING

Wire Company, Pittsburgh Crucible Steel Company, Republic Steel Corporation and National Tube Company.

J. H. Richardson, Gulf Coast district manager for Koalt Engineering Company, Tulsa, has resigned to open and manage an office in Denver, Colorado, for Key Company, East St. Louis, Illinois. Neff S. Cass, manager of Koalt Engineering Company's Dallas office, will succeed Richardson at Houston.

W. F. Rockwell has been appointed chairman of the nominating committee to select representatives to consult with OPM on the transfer of automotive activities to the national defense. Rockwell is board chairman of Timken-Detroit Axle Company and president of Pittsburgh Equitable Meter Company.

A. F. Stadler has been named assistant purchasing agent for Frick Reid Supply Corporation.

Leslie S. Gillette, Chicago Pneumatic Tool Company, has been re-elected president of the New York Sales Managers' Club.

C. E. Morris has been appointed by John Zink Company, Tulsa, as manager of the Dallas branch at 2405 South Harwood. He is a University of Texas graduate.

Earle W. Gard, manager of research and development for Union Oil Company of California, has joined Bechtel-McCone-Parsons Corporation, Los Angeles. A 1917 graduate of University of Southern California with degrees in electrical and chemical engineering, he was assigned to the Bremerton navy yard during the first World War. He joined Union Oil Company in 1919, and was assigned to process development. He left the company for a short period, rejoining as assistant to the late R. E. Haylett, director of manufacturing, and in 1933 was placed in charge of development, engineering design, construction and operation of new processes. He was made manager of research and development in 1938.

Wheelco Instruments Company has moved to its own plant and office building at Harrison and Peoria Streets, Chicago, marking its third major expansion since organization in 1935.

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COPPER SWEETENING PROCESS

Nichols
TRIANGLE BRAND
COPPER SULPHATE

is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

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Quotation on request, on any quantity required. Prompt shipments can be made from our nearest plant.

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